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# Properties of Concrete with Incorporation of Hybrid Fibers and M-Sand-A Review

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***Abstract***

*The construction sector is experiencing rapid growth, resulting in an increasing demand for building materials. Concrete, being the building material that sees the most widespread usage, Concrete, as the most extensively used building material, plays an important part in future breakthroughs and advancements However; to make progress we must also address the problems of global warming and pollution. The construction sector is widely considered to be one of the biggest polluters. To encourage sustainability in construction, eco-friendly practices must be integrated into the industry's core. One approach involves enhancing the sustainability and eco-friendliness of concrete by incorporating waste materials as additives or replacements. Utilizing various Fiber Reinforcement Composite material in concrete not only offers strength advantages but also adds aesthetic appeal to environmentally friendly concrete. Additionally, Natural Natural sand compared with manufactured sand (M-Sand) is another viable option. This is how we minimize stone waste. The building sector may contribute to sustainability efforts while satisfying development demands by utilizing these waste materials and their unique features.*

**Keywords:** Hybrid Composite, fibers, eco-friendly concrete, M-Sand, sustainable construction, Fiber Reinforcement Composite material, graphite fiber-reinforced polymer

## INTRODUCTION

In the contemporary era marked by economic expansion and technological progress, the construction of large-scale structures, such as residential and commercial skyscrapers, is witnessing a global upswing. As developing nations actively pursue extensive economic growth, the imperative to adopt sustainable practices becomes paramount. Concrete, a leading material in the construction industry, is essential to these advancements. Nevertheless, the rapid proliferation of the modern concrete landscape brings about significant environmental repercussions, impacting both living organisms and the planet at large. To tackle these challenges, placing sustainable development at the forefront of the construction sector is essential. Researchers are actively engaged in developing environmentally friendly concrete by integrating waste products into the mixture [9]. Notably, natural sand, a widely consumed non-renewable resource in construction, is central to this discussion. In the pursuit of concrete for construction, there has been a drastic increase in natural sand mining over the past few decades. Natural sand, crucial for maintaining environmental equilibrium in riverbeds face deterioration Because of extensive mining activities [11, 12]. This has far-reaching consequences, including changes in river. flow directions, floods, and adverse effects on biological diversity. From 2010 to 2020, there was a notable increase in the utilization of natural sand in the Indian construction industry, rising from 630 to 1400 million tons. Due to the acknowledged issues linked with natural sand mining, various nations have implemented prohibitions on its incorporation as fine aggregates in concrete.

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Therefore, the quest for alternative, environmentally friendly solutions for sand and concrete becomes imperative for further development without exacerbating environmental harm. However, conventional concrete exhibits weak flexural strength compared to various construction materials, including innovative products [10]. Addressing this, the integration of diverse fibers emerges as a viable strategy to enhance the tensile strength of concrete, mitigating issues such as chipping and cracking that can escalate over time.

**Various Fibers Utilized in Concrete**

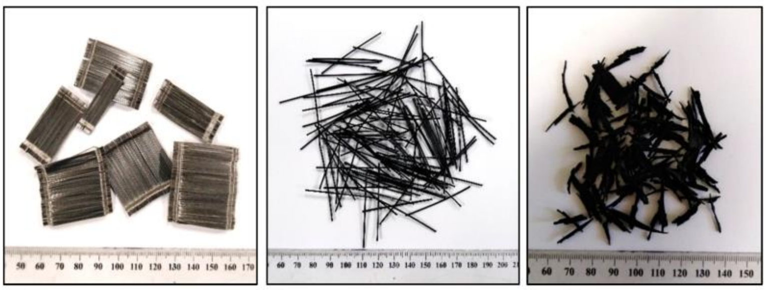
Fiber Reinforced Concrete (FRC) finds diverse applications in the construction sector, including pavements, airfield aprons, and precast pipes. Choosing fibers for concrete is tailored to the specific requirements of each application, with different materials imparting unique properties to the concrete. Incorporating steel fibers into concrete serves to enhance its flexural strength, effectively transforming a brittle material into a more pliable substance. This improvement in flexibility is particularly advantageous in scenarios where the concrete needs to withstand bending forces. Glass fiber & Polypropylene fibers play a distinct role by mitigating shrinkage and reducing permeability in concrete. This characteristic expands the temperature range within which the concrete can perform optimally. Glass and polypropylene fibers help to prolong the overall toughness and lifespan of the concrete structure by addressing problems with shrinkage and permeability. In order to achieve an effective FRC mix, maintaining control over the aspect ratio is essential [6]., which represents the ratio between the length and diameter of the fibers. Proper management of this ratio ensures the successful integration of fibers into the concrete matrix, enhancing the efficiency of Fiber Reinforced Concrete [25]. In summary, the choice of fibers for concrete reinforcement is application-specific, with steel fibers enhancing flexural strength and polypropylene fibers addressing shrinkage and permeability concerns also we can use Hybrid Fiber Laminates for enhanciing the mechanical properties of concrete [19]. Careful regulation of the aspect ratio is essential to guarantee the formulation of a well-balanced Fiber Reinforced Concrete (FRC) mix customized to fulfill the requirements of diverse construction applications (Figure 1) also Integrating fibers into concrete mixtures offers numerous advantages, enhancing both the performance and durability of concrete structures. Below, we examine the varieties of fibers employed in concrete reinforcement and the advantages associated with their use.

*Steel Fibers:* Enhance structural strength and durability, particularly in industrial floors and pavements.

*Glass Fibers:* Applied to decorative concrete applications, they offer resistance against tensile stresses.

*Synthetic Fibers:* Such as polypropylene (thermoplastic polymer), nylon or hybrid textile polymer composites [27], are effective in controlling shrinkage cracks and improving impact resistance.

*Natural Fibers:* Like cellulose, offer eco-friendly options and improve concrete’s toughness and crack resistance.



Steel fibres Polypropylene fibres Rubber fibres

**Figure 1.** Various fiber additives used in concrete [17].

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**Benefits of m-sand**

Using manufactured sand (M-Sand) in concrete offers several advantages that contribute to improved construction performance and environmental sustainability. Here are some key advantages:

- *Consistent Quality:* M-Sand is produced through advanced processing techniques, ensuring consistent particle size and quality [8]. This uniformity leads to more predictable and reliable concrete properties.
- *Grading Control:* The production process allows for better control over the grading of particles, resulting in a well-graded and well-shaped aggregate. This enhances the workability of the concrete mix.
- *Reduced Environmental Impact:* Unlike natural sand, the extraction of M-Sand does not involve significant environmental disturbance, such as riverbed mining. using M-Sand, the environmental impact of sand extraction is lessened and natural resources are preserved.
- *Cost-Effective:* M-Sand production can be more cost-effective than extracting and processing natural sand. The availability and accessibility of M-Sand in certain regions can contribute to cost savings in transportation as well.
- *Conservation of Natural Resources:* The use of M-Sand helps in conserving natural natural sand, which is often over-exploited due to high demand in construction. This conservation contributes to sustainable resource management.
- *Control over Particle Shape:* M-Sand production allows for better control over the shape of particles. This is particularly advantageous in concrete applications where particle shape can influence the workability and strength of the mix.
- *Reduced Dependency on Natural sand:* In regions where, natural sand is scarce or faces environmental restrictions, M-Sand provides a viable alternative, ensuring a stable supply of sand for construction.
- *Mitigation of Environmental Issues:* The extraction of natural sand often leads to environmental problems such as soil erosion, disruption of aquatic ecosystems, and alteration of river channels. The use of M-Sand helps mitigate these environmental issues.
- *Less Impact on River Ecosystems:* Since M-Sand does not require extraction from riverbeds, it helps in preserving the natural equilibrium of river ecosystems and prevents the adverse effects associated with excessive sand mining.
- *Quality Control in Production:* M-Sand production involves controlled processes that enable quality checks and adherence to standards, reducing variability in the concrete mix and enhancing overall construction quality.

## LITERATURE REVIEW

A thorough literature survey was undertaken to identify pertinent studies and research articles that delve into the integration of M-Sand and fibers in the manufacturing of concrete. This comprehensive review involved searching various databases and academic sources utilizing relevant keywords. The selected studies underwent rigorous scrutiny to extract pertinent information, and the findings were subsequently analyzed to garner insights into the advantages, limitations, and potential future directions associated with the utilization of Utilizing these waste materials as fine aggregates in concrete production.

*Mohammad et al. (2022)* The study involved investigating specific Characteristics of both fresh and hardened concrete, encompassing aspects such as workability and compressive strength, and abrasion resistance. The concrete was reinforced with both steel and tire fibers in various proportions of the concrete volume (0%, 0.25%, 0.75%, 1%). The findings revealed that with a Rise in the quantity of steel fiber, there was a corresponding Resulting in an augmented compressive strength, the mixture that includes 1% steel exhibited a higher compressive strength, showing a 25.74% improvement over the 0% mix. Additionally, the compressive strength of the 1% Tire Fiber Reinforced Concrete (TFRC) was observed to be 2.31% exceeding that of the 0% Fiber concrete [20].

*Kumar et al. (2022)* concluded that reinforcing Geopolymer Concrete (GPC) with fibers can lead to enhanced strength properties and other advantages. The findings suggest that fiber-reinforced geopolymer Concrete possesses the potential for application in structural uses [21].

*Ali et al. (2019)* investigates Three types of concrete mixes are manufactured employing 0% Recycled Concrete Aggregate (RCA), 50% RCA, and 100% RCA. In each of these three mix variations, volume fractions of Glass Fibers (GF) are incorporated at rates of 0%, 0.25%, 0.5%, 0.75%, and 1%. It was observed that higher dosages (>0.5%) of GF have a more adverse impact on the durability of concrete compared to lower dosages of GF (<0.5%) [1].

*Faried et al. (2021)* stated that Several UHPC mixes with nanomaterial dosages (1%, 2% and 3%) were investigated and found Compressive strength increased by 17%, 24%, 14% and 13% under IC in NWG, NRH, NMK and NS, respectively. By contrast, sorptivity decreased by 84%, 60%, 48% and 60% in NS, NMK, NWG and NRHA under IC [2].

*Parashar et al. (2020)* investigates incorporation of steel fibers and glass fibers at the optimal replacement level of bagasse ash in concrete. Concrete samples of M30 grade were created, incorporating bagasse ash replacements at percentages of 5, 10, 15, and 20. Additionally, hooked steel fibers and glass fibers were introduced in varying proportions, ranging from 0.50% to 1.25% (increment of 0.25%) and 0.5% to 2% (increment of 0.5%), respectively. The mechanical properties displayed improvement up to a 10% bagasse ash replacement, beyond which a decline was observed. The most significant enhancements in flexural, compressive, and split tensile strength were noted for the BA10 specimen after 28 days, exhibiting increases of 6.50%, 13.09%, and 8.13%, respectively. The incorporation of hooked steel fibers yielded optimal strength for the BASF-C sample, with increments in flexural, compressive, and split tensile strength reaching 8.89%, 18.44%, and 18.80%, respectively. Conversely, the highest strength with glass fibers was attained in the BAGF-C specimen, demonstrating increases in flexural, compressive, and split tensile strength of 8.12%, 14.29%, and 10.03%, respectively [22].

*Prathipati et al. (2020)* observed that the Hybrid Fiber [18] Reinforced Concrete (HyFRC) mixes' toughness index, ductility, and strength values were noticeably higher than those of the non-hybridized HyFRC mixes. This suggests a positive synergy in integrating graded fibers into the concrete [23].

*Prathipati et al. (2020)* determined that the fiber distribution properties have significantly improved as a result of the addition of steel and glass fibers of various lengths to the concrete [24].

*Murali et al. (2020)* investigates the impact response of Polymer-Enhanced Air-Entrained Fiber Concrete (PEAFC) incorporating Glass Fiber Mesh (GFM) with various layers and diameters, along with 0.2% of Multi-Walled Carbon Nanotubes (MWCNT) and a 2.5% dosage of Silica Fume (SF). Concrete specimens containing 2.5% SF and 0.2% MWCNT exhibited a noteworthy increase in compressive strength, reaching 67.5% compared to reference specimens [3].

*Naqvi et al. (2017)* investigated the behavior of six full-scale lap-spliced glass fiber-reinforced polymer (GFRP) reinforced concrete rectangular columns. The conclusion drawn was that the addition of steel fibers not only prevented concrete spalling but also enhanced the confinement and deformability of GFRP-RC Columns with inadequate lap splice length. Moreover, it was noted that increasing the steel fiber content from 1% to 2% did not result in further improved performance [13].

*Zeyad et al. (2022)* stated that highest compressive strength of 180.6 MPa was achieved using Ilmenite aggregate and steel fiber, the best radiation protection properties were achieved using lead fiber and magnetite aggregates when observed properties of ultra-high-performance (UHPC) and heavyweight radiation shielding concrete (UHPHSC) [4].

 

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*Zhang et al. (2022)* conclude that Steel fiber reinforced concrete (SFRC) can exhibit superior performances of high strength and toughness Because of the enhancing effect of discontinuous steel fibers randomly distributed in concrete matrix [5].

*Fattouh et al. (2023)* stated that TW-cured concrete for MCC, MSFRC and MSFRC–SF increased by 23.73%, 23.57%, and 25.14% in compressive strength from 7 days to 28 days. Within the same period, SW-cured concrete compressive Strength saw an increase of 23%, 26.39%, and 22.53% for MCC, MSFRC, and MSFRC–SF mixtures [15].

*Jiao et al. (2023)* explores three combinations of single fibers and nine combinations of hybrid fibers to analyze the the mechanical characteristics and crack propagation behavior of ultra-high-performance concrete (UHPC) using digital image correlation. The findings indicate that, compared to single fibers, long fibers had a more significant impact than short fibers. Particularly, the hybrid combination of medium-length fiber (Vf = 0.5%) and long fiber (Vf = 1.5%) exhibited superior flexural behavior concerning post-crack strength, deflection, and toughness in comparison to the others hybridization series [7].

*Wang et al. (2022)* investigated three groups with ratios of water to binder. 0.15, 0.17, and 0.19, respectively. Each group had varying fiber contents of 1.5%, 2.0%, 2.5%, and 3.0%. The evaluation of test results utilized the JG/T-472–2015 and CECS13 methods. The findings indicated that the highest toughness efficiency was observed when the fiber content ranged from 1.5% to 2%. Pearson correlation coefficients were found to be an effective method for assessing the relationships between compressive strength and equivalent flexural strength, as well as peak load and peak deflection of specimens [16].

*Aisheh et al. (2022)* observed that adding steel fibers reduced the fresh ultra-high-performance geopolymer concrete composite mixtures' workability. As the fiber dosage rose, the workability decreased [14].

*Sonkusare et al. (2021)* investigates Uses of silica sand in RPC and identify structural changes occur in compression strength and conclude that substituting a portion of silica fume and silica sand gives the optimum value on 14% and 6% for higher strength [26].

## CONCLUSION

The analysis of various research studies indicates that Hybrid Fiber Reinforced Concrete (HyFRC) mixes with a higher proportion of large fibers have shown significant enhancements in flexural strength. Nano waste materials demonstrated the highest percentage improvement in strength under the Standard Curing method, as well as the control mix, compared to other curing methods. A significant effect of Glass Fiber dosage is seen in the ratio of compressive strength to flexural strength. Incorporating Condensed Silica Fume (CSF) and metakaolin at a modest percentage of 5% each has further elevated the strength properties. In cement mortar, a 50% replacement of natural sand with manufactured sand results in greater compressive strength in comparison to the regular mix. Both compressive and flexural strengths show an increase as the percentage of M-Sand is raised up to the optimal level. The optimum replacement percentage of natural sand by M-sand is determined to be 50%. Nevertheless, additional research is essential to fine-tune mix proportions, address compatibility issues, and assess the long-term performance of such concrete. The knowledge obtained from this review can act as a foundation for future research and development in this field, encouraging the adoption of eco-friendly practices in the construction sector

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