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# A Review on Mechanical and Durable Properties of Fibre Reinforced Concrete

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**ABSTRACT:** Fiber-reinforced concrete (FRC) is concrete made primarily of hydraulic cements, aggregates, and discrete reinforcing fibers. Fibers suitable for reinforcing concrete have been produced from steel, glass, and organic polymers (synthetic fibers). Fiber reinforced concrete (FRC) overlays are used for repairing and reinforcing pavements. In this research, some experimental tests performed to investigate the effects of steel and synthetic fibers on the performance of the concrete overlay. The synthetic fiber in this study is based on Modified Synthetic Polypropylene (MSP) Fiber. Plain and FRC specimens underwent flexural and compressive strength, and durability tests. The results show that the use of MSP in concrete overlays increases compressive and flexural strength, residual strength, ductility, and energy absorption, and reduces the resistance of concrete against freezing and thawing cycles.

**KEYWORDS:** Fibre reinforced concrete, Compressive strength, Durability.

## I. INTRODUCTION

Fiber-reinforced concrete (FRC) is concrete made primarily of hydraulic cements, aggregates, and discrete reinforcing fibers. Fibers suitable for reinforcing concrete have been produced from steel, glass, and organic polymers (synthetic fibers). Concrete has been widely used because of its availability, high temperature resistance, high compressive strength and stiffness. However, concrete is prone to crack under the effect of vehicle and environment loading because of its low tensile strength. Adding fibers to concrete is one of the effective ways to improve its tensile strength and ductility, as well as frost resistance. Thus, the steel fiber reinforced concrete has been widely used in architecture and bridge structures. Nevertheless, steel fiber is expensive compared with the ordinary concrete. Therefore, mechanical performance of polymer fibers reinforced concrete has been researched. High-performance synthetic fiber (HPSF) has high-tensile strength, good acid and alkali resistance, high temperature resistance, but light weight and low cost. Thus, the high-performance synthetic fiber reinforced concrete has a potential advantage over other types fiber reinforced concrete. The published research shows that the HPSFRC has superior mechanical performance (tensile strength and fatigue life) over the ordinary concrete. However, research on the durability of the HPSFRC is scarce.

Research on durability of fiber concrete, on the other hand is very limited and the results are contradictory. Therefore, the determination of concrete properties related to its durability can provide useful knowledge about the lifetime of these structures.

## II. RELATED WORK

Hasaniet al., ascertained that fiber reinforced concrete (FRC) overlays are used for repairing and reinforcing pavements. In this research, some experimental tests performed to investigate the effects of steel and synthetic fibers on the performance of the concrete overlay. The synthetic fiber in this study is based on Modified Synthetic Polypropylene (MSP) Fiber. Plain and FRC specimens underwent flexural and compressive strength, and durability tests [9][10][11]. The results show that the use of MSP in concrete overlays increases compressive and flexural strength, residual strength, ductility, and energy absorption, and reduces the resistance of concrete against freezing and thawing cycles. Using similar addition volume, Steel Fiber Reinforced Concrete (SFRC) has better flexural performance and lower

compressive strength and workability than Modified Synthetic Polypropylene Fiber Reinforced Concrete (MSPFRC). To determine the thickness of the bonded concrete overlay (t), the Portland Cement Association (PCA) design criteria were used. In this study, these criteria simulated using finite element (FE). The results showed that the use of MSP in concrete overlays could reduce the thickness of bonded concrete overlay up to 15%.

Ghanem researched that fresh and mechanical properties of self-consolidating concrete (SCC) reinforced by synthetic polymer fibers. The influence of hybrid fiber reinforcement on these properties and the effect of fiber manufacturing method are reported. Eight mixtures on which seven are reinforced with a fiber volume fraction of 1% with varied percent of macro and microfibers are investigated. The concrete density, filling ability, passing ability, segregation, compressive strength, and splitting tensile strength are recorded. The test results showed that the higher the macro fibers in the mixture, the denser the concrete and the less macro fibers in the hybridization, the higher the slump flow. For mixtures with hybrid fibers, the compressive strength decreases with increasing microfiber percent. The combination of macro and microfibers achieved higher tensile strength than the single fiber mixture. The research also found that when compared with concrete reinforced with monofilament polypropylene fibers, concrete reinforced with a collated fibrillated fiber is less flowable with less passing ability, lower compressive and splitting tensile strength. Multivariable regression was also conducted for all investigated properties to optimize the volume fraction for each fiber type. Almost the same properties were observed [8].

Chakravarthy et al., informed that trial examine was finished to consider the flexural conduct of high quality cement for target quality of 80 MPa utilizing snared end steel fibres, pleated steel fiber in different volume parts of the extents 0.25%, 0.50% and 0.75% the High quality cement (HSC) is accomplished with the assistance of silica fume and superplasticizer for more noteworthy quality and solidness. The bridging action of fibre helps to arrest the crack propagation. The compressibility characteristics break rigidity what's more flexible quality has expanded whenever differentiated with the ordinary concrete. Compressive strength characteristics has expanded up to 5.88%, Split Tensile strength expanded by 38.71%. The flexural strength is expanded by 6–12% [15], [16], [18]. The chloride permeability is very low in all the types of concrete with and without fibres as per ASTM C 1202. The water penetration is almost NIL in all the mix which shows that the closely spaced cement matrix contributes to this behaviour.

Söylevet al., observed that steel, polypropylene, and glass fiber concretes at low-volume fractions, which have been successfully used for crack control in many structural applications, were tested for different properties including water absorption, electrical resistivity, sorptivity, depth of chloride penetration, chloride profiles, rebar corrosion half-cell potential, and corrosion current density. Compressive strength and splitting tensile strength, flexural strength, and fracture toughness were also determined [19], [20]. Two different water–cement ratios and two curing types were used in the study. Fibers caused physical changes in concrete, which were reflected to the tested properties. The effect on durability was more significant in longer-term tests like corrosion. Moist curing was found to be more effective in fiber concrete for mechanical properties.

Meng et al., researched that experimental research on durability of high-performance synthetic fibers reinforced concrete (HPSFRC) is conducted based on its excellent mechanical performance. The results indicate that HPSFRC shows superior resistances to sulfate attack and freezing-thawing over the ordinary concrete due to its excellent anti-crack performance. HPSFRC has an optimum dosage of high-performance synthetic fiber (HPSF) for achieving good mechanical performance and durability [12], [13], [14]. Additionally, the influences of freezing-thawing cycles, concentration of sodium sulfate solution, and fiber content on the freezing-thawing resistance of HPSFRC are analyzed using response surface methodology. The analysis results show that the freezing-thawing cycles have the most significant influence on freezing-thawing resistance, followed by concentration of sodium sulfate solution and fiber content.

de Souza Castoldiet al., ascertained the aims to compare the mechanical behavior of concretes reinforced with polypropylene and sisal fibers. Both fibers were 51 mm long and were incorporated in fractions of 3, 6 and 10 kg/m<sup>3</sup>

into the matrices. The composites were tested under three-point monotonic and cyclic flexural loads. Pullout tests were performed to study the fiber-matrix interaction. It was observed that the sisal fiber could provide the same level of residual strength as the polypropylene fiber, as long as the equivalence of the dosages of the fibers is taken into account. The composites were classified according to fib Model Code 2010 based on parameters obtained from flexural tests. The durability of the composites was studied by assessing the flexural behavior after wetting and drying cycles. Concrete reinforced with both fibers did not present mechanical losses after the cycles.

Wang et al., informed that the synergistic effect of combining macro polypropylene (PP) fiber and rubberized concrete was evaluated based on mechanical and durability performance, as well as microstructure. The specimens were prepared with two different rubber volume contents at 10% and 15%, incorporating with a consistent fiber volume fraction of 0.5%. The plain concrete specimens and specimens with only PP fiber were also produced for comparison. The mechanical test results indicated that the fracture energy of plain concrete could be enhanced with both macro PP fiber and rubber aggregates. Besides, all specimens achieved compressive strength higher than 40 Mpa, and the ultrasonic pulse velocity demonstrated the good quality of concrete specimens. The fracture morphology and ESEM imaging showed the positive function of rubber aggregates and PP fibers on the post-crack propagation. The durability performance, including drying shrinkage, ASR expansion, and frost resistance were also strengthened in macro PP fiber-reinforced rubber concrete compared with plain concrete. The macro PP fiber-reinforced rubber concrete will enlarge the post-failure flexural residual load capacity and deformation and distribute stress for multiple crack propagation, thus increasing overall fracture toughness and reducing brittleness. The sustainable applications can be further explored with the combination of macro PP fiber and recycled rubber aggregate.

### III. EXPERIMENTAL RESULTS

Concretes reinforced with synthetic (polypropylene) and natural fibers were investigated by means of flexural tests, under monotonic and cyclic loads. Pullout tests were also carried out to evaluate the differences between the interfaces of both fibers. Moreover, durability tests were performed to assess the influence of wetting and drying cycles on the mechanical behavior of these composites [6]. The evaluation of macro PP fiber reinforced rubberized concrete showed the synergy effect by hybridizing macro PP fiber and rubber aggregates in concrete material. It could become a cost-effective, environmental-friendly, and durable material for civil construction [7]. The fresh and mechanical properties of self-consolidating concrete (SCC) containing hybrid synthetic polymer fibers. The hybridizations are based on the fiber dimensions and manufacturing method. A total of eight mixtures are studied, of which seven are reinforced with a fiber volume fraction of 1% using several percent of macro and microfibers. The concrete mixtures' density, filling ability, passing ability, segregation, compressive strength, and splitting tensile strength are determined. Statistical analysis is also carried out on the data obtained to optimize each fiber's volume fraction in the hybridization [2]. Test results on freezing-thawing resistance of the HPSFRC in the medium of water and 5% sodium sulfate solution show that the HPSFRC also has superior freezing-thawing resistance over the ordinary concrete. The freezing-thawing resistance of the HPSFRC in water is stronger than that in the sodium sulfate solution. Additionally, the sodium sulfate solution has joint effect of sulfate attack and freezing thawing on concrete. Besides, an empirical model to predict the damage degree has been developed based on Weibull distribution of fatigue equation. [5]. The development of corrosion was slower in w/c-0.45 concrete and there was no cracking of concrete until the end of testing. There was no significant difference at early ages of chloride exposure, however long-term rebar corrosion measurements enabled to distinguish the differences between the corrosion resistances of 0.45-w/c concretes with different fibers. Polypropylene and glass fiber concretes exhibited higher rate of rebar corrosion. The results showed that fiber addition can significantly affect the resistance against corrosion. This effect becomes significant in long-term exposure and can be critical for the lifetime of a concrete structure [4]. The compressive quality of the mixture fiber strengthened cement HY80M1 is expanded by 5.88% of when contrasted with the traditional concrete. The fibres hooked steel (0.75%) and crimped steel (0.25%) when added to the concrete the enhancement was only marginal in the order of 4.32% at the point when contrasted with regular concrete. The addition of crimped fibres by 0.75% and hooked steel fibres of 0.25%



to the concrete has yielded only 3.36% when compared to conventional concrete which is marginally less compared to hooked steel 0.75% and crimped steel 0.25%. The split rigidity of the elite hybrid fiber strengthened concrete is improved by 33–37% than simple control cement's elasticity. Snared steel strands get expanded in bigger volume increases the tensile strength contrasted with creased fibres. The water penetration is almost NIL in all the mix which shows that the closely spaced cement matrix contributes to this behaviour. The flexural quality of concrete is expanded by 6–12% when fibres in the hybrid structure are mixed with concrete. The strands increase the rigidity more than the compressive quality because of essence of steel fibres is an apparent. The chloride permeability is very low in all the types of concrete with and without fibres as per ASTM C 1202 [3]. Resistance of MSPFRC against freezing and thawing cycles is less than PC, and decreases by increasing fiber content [22]. In the same volume percentage, SFRC had a better flexural performance than the MSPFRC. Also, the SFRC had less workability and compressive strength than the MSPFRC. Residual strength, flexural toughness factor, and toughness index for SFRC respectively were about 5, 3 and 2 times more than the MSPFRC. [1]

#### IV. CONCLUSION

We have found better results are obtained by using fibre reinforced concrete. Hence fibre reinforced concrete can be used as an alternative for regular concrete.

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