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PAST INVESTIGATIONS ON MECHANICAL AND DURABILITY PROPERTIES OF HYBRID FIBER REINFORCED CONCRETE

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ABSTRACT

In recent years fibers has been widely utilized for strengthening of concrete structures due to its high tensile and flexural properties. In this paper, an introduction is given on the properties of different fibers used for structural applications. Moreover, a brief review of the past investigations on different fibers and the use of metallic, natural and synthetic fibers on improvement in hardened and durability properties of concrete are also highlighted. This paper shall focus on literature review on strength and durability properties of hybrid fibers Steel/polypropylene/glass and carbon fiber reinforced concrete.

Key words: Experimental Investigations on Hybrid Reinforced Concrete- Mechanical and durability Properties Study- Future Prospects.

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1. INTRODUCTION

It is outstanding that Conventional concrete is a delicate material under tensile loading. The mechanical properties of concrete can be improved by haphazardly arranged short discrete fibers which avert or control commencement, proliferation, blend of cracks. The inclusion of fibers to concrete in the said sums impacts hardened concrete properties; improvement in toughness and energy assimilation; accomplishment of higher protection from dynamic load and decrease in crack dispersing and width. By utilizing mixture of fibers in a concrete mixture the similar properties of concrete can be obtained as those shown by regular fiber strengthened concrete yet with the inclusion of a littler quantity of fibers. Also, the utilization of a mono kind of fiber may improve the properties of FRC to a restricted level. Anyway the idea of hybridization, which is the way toward including at least two kinds of fibers into concrete, can offer progressively appealing designing properties as the nearness on fibers empowers the more productive usage of the potential properties of alternate fibers.

Fiber strengthened concrete (FRC) is certainly not a new idea. Since scriptural occasions fibers were utilized in establishing development materials as straw and pony hair (Brandt, 2008). In later occasions the asbestos fiber was utilized broadly in auxiliary parts like divider boards, rooftops and doors to name a view. In the mid 1960's the wellbeing danger of assembling and utilizing asbestos filaments ended up clear and elective strands were presented as a substitution (Labib and Eden, 2004).After asbestos strands, steel strands was one of the principal conceivable choices to steel bar reinforcing, with the main patent being connected for in 1874. It was anyway just in the mid 1970's that the utilization of these strands on an extensive scale was seen in the USA, Japan and in Europe

2. PAST INVESTIGATIONS ON HARDENED AND DURABILITY BEHAVIOUR OF HFRC

W Sun, et al (2000) author reported that:

- The durability is the ability to keep going quite a while without critical weakening. Hybrid fiber fortified workability concrete (HFRC) turns out to be tough material, which is compelling in opposing the harm caused because of freezing and defrosting because of synergistic execution of mixture of two different fibers.
- It has been reasoned that the execution of hybrid fibers in concrete is superior to anything that of mono fiber concrete for improved durability in opposing the ruinous impact of freezing and defrosting and furthermore for strength upgrade.

Qian C.X et al (2000) author noted that:

- The strengthening proficiency of hybrid fibers in the low amount fly ash concrete up to 30% substitution of concrete.
- Micro mechanical activity of hybrid fibers in fly cinder based concrete will be improved as for various proportion of steel and polypropylene fiber addition.
- The ideal level of fly ash substitution ought to be between 10 to 30% so as to acquire most extreme strength of the concrete.

Skazlic. M et al (2001) author reported that:

- A survey on the superior high volume fly ash concrete fortified with hybrid fibers tried to substitute fly ash for concrete which by and large prompts lower quality
- They found that steel fiber which is stronger and stiffer, improves the concrete quality, while polypropylene fiber has the ability to reinforce fragile cementitious materials and is progressively adaptable and has the property to hold heat for a drawn out time which prompts improved strength, and strain limit in the post splitting area and retard early cracks.

Alwan JM et al (2002) author noted that:

- The utilization of superior composite strands takes into consideration the improvement of the mechanical properties of concrete composites.
- Mechanical properties of such composites are resolved prevalently by the interface properties between the fiber and cementations' network.
- The consequences of these tests enable explicit plan parameters to be assessed quantitatively.

Banthia, N et al (2003) author investigated that the :

- Utilization of various fiber as reinforcement in concrete for a more prominent durability, functionality and decrease in crack.
- The fiber introduction assumes a critical job to decide the compressive strength, which relies upon the mixing.
- FRC controls the miniaturized cracking, shrinkage and determination under load much superior to plain concrete.

Wu Yao, et al (2003) author concluded that:

- Concretes containing diverse kinds of hybrid fibers at a similar volume part (0.5%) were looked at regarding compressive, splitting tensile, and flexural strength.
- Three types of hybrid composites were constructed utilizing fiber combination of polypropylene (PP) and carbon, carbon and steel, and steel and PP fibers.
- Test outcomes show that the strands, it utilized in hybrid fiber, should result in better composite execution looked at than their individual fiber-strengthened concretes.

Songs PS. (2004) author concluded that:

- The greatest increment in the compressive strength, modulus of elasticity, and Poisson's proportion because of the addition of steel fibers was observed to be very little under 10% in different grades (GRD) of concrete 35, 65, and 85 MPa.
- The most extreme increment in the strain relating to the peak compressive strength was observed to be about 30% in different grades of concrete 35, 65, and 85 MPa.

Marijan Skazlic and Dubravka Bjegovic (2004) author reported that:

- Hybrid fiber-strengthened concrete is a sort of fiber-fortified concrete portrayed by three kinds of steel strands and two sorts of polypropylene filaments were utilized in analyses. Hardened properties and sturdiness properties were estimated.
- The investigation of the outcomes, acquired for the said properties of half breed and plain fiber-strengthened concrete in solidified state.

Horiguchi et al (2004) author reported that:

- Residual strength of the polypropylene fiber reinforcement demonstrates the most elevated quality loss in the wake of warming at 200 C and 400 C.
- While the most highest quality loss of high quality concrete 400^0C was 60% the hybrid and steel fiber reinforcement mitigates this strength up to 40%. The fracture energy at 200^{0C} was build by the steel, polypropylene and hybrid fibers.
- The crack energy of hybrid fiber fortified high quality concrete held moderately higher incentive than of the polypropylene fiber strengthened high quality concrete.

EI- Tawil et al (2007) author examined that :

- Impact of hardened properties of glass fiber and steel fibers in the concrete.

- In compressive quality (CS), flexural quality (FS) and split rigidity, the addition of Steel fiber the strength is increasing straightly, yet in glass fiber up to 1% it is increasing and from 2% it is diminishing.
- It is reasoned that the quality is expanding while at the same time increasing the level of steel fiber.

Kim DJ et al (2007) author noticed that:

- A steel fibers in a concrete enhance all the mechanical properties of concrete, particularly tensile strength, impact strength and toughness.
- The subsequent material has higher rigidity, combined reaction and better ductility.
- The recommended condition relates the split elasticity of steel fiber strengthened concrete with compressive strength and fiber support index Concrete compressive strength.

M.di Prisco et al(2009) author investigated that:

- A Fiber Reinforced Concrete (FRC) is a composite material consisting of cement based matrix with an ordered or random distribution of fiber which can be steel, nylon, polythene and so on.
- Expansion in innovation improves human solaces as well as wreck the eco-framework.
- Fiber Reinforced Concrete is commonly made with M40 grade concrete and low water content. Steel Fiber 1.5% expansion improves probability of concrete and its post-breaking load conveying limit.
- Increases the shape compressive quality 40.00 Mpa concrete in 7 days The most vital commitment of fiber fortification in cement isn't to quality however to the flexural quality 18% solid materials.

S.P.Singh, et al (2010) author investigated that:

- Investigation led to examine the impact of fiber hybridization on the quality attributes such as compressive quality, splitting tensile strength, and water permeability of steel fiber strengthened concrete (SFRC) are displayed.
- Properties of HSFRC containing mix proportion of steel fibers of various size and plain concrete is hardened state have been investigated.
- Tests such as compressive quality, splitting tensile strength, and water permeability were conducted on concrete after 7, 28, 90, and 120 days of curing.

S. Taner Yildirim, et al (2010) author concluded that:

- The execution under effect loads was exceptionally positive particularly in half and half fiber fortified cement including glass fiber.
- The polypropylene fiber was the more viable than glass fiber fortified cement including 1% volume percent steel fiber. The fibers reduce the cracks in concrete and the miniaturized scale or full scale structures of fibers had likewise got a vital impact.
- While miniaturized scale organized polypropylene, and glass fibers diminished the smaller scale cracks then again large scale organized hooked end steel fibers diminished the full scale cracks.

Hamad BS et al (2011) author examined that:

- The impact of fibers was not seen in improving the pre-split execution of the test specimen, while a ultimate bond quality and post peak bond quality execution expanded fundamentally.
- The extreme bond quality is observed to be unequivocally influenced by the compressive quality as opposed to fiber volume. Brittle failure was more pronounced in specimens with bigger sizes.

- The irregular post peak profile of load-slip curve resulting from this brittleness changed to smooth consistent one as the fiber dosage increased Fibers were found to influence both the ultimate bond strength and post maximum bond strength.

Y. Y. Zhou et al (2012) author investigated that:

- Polypropylene Fiber Reinforced Concrete is an embryonic development material which can be portrayed as a solid having high mechanical quality, Stiffness and toughness.
- By use of Polypropylene fiber in cement ideal use of materials is accomplished as well as the cost decrease is accomplished.
- Polypropylene fibers diminish the water porousness, plastic, shrinkage and settlement and carbonation depth. Workability of concrete with increase in polypropylene fiber volume fraction.
- Polypropylene strands improve the quality of concrete, without causing the outstanding issues, ordinarily connected with steel fibers.

Corinaldesi V et al (2012) author concluded that:

- The mechanical property of hybrid fiber reinforced concrete is more than the strength of normal concrete.
- A rate of strength gain for 7 days strength of HFRC is very high as compared to conventional concrete.
- As % of fiber increases the split tensile strength also increases. Workability drastically decreases when coconut fiber content is increased in concrete.

Muhammed Yasin Durgun et al (2012) author concluded that:

- In their examination, experimental mechanical properties of concrete specimens, with a (w/c) proportion of 0.47 and having a reference slump of 40 mm, delivered by addition of steel fibers as well as polypropylene fibers, were researched.
- It fiber consideration to solid abatements the workability and that the mechanical properties of cement can be improved by the expansion of fibers.
- Mechanical properties of concrete can be improved by the addition of fibers. Utilizing monofibers in the concrete marginally builds the compressive strength of concrete

M. Tamilselvi et al (2013) author noticed that:

- The increment in compressive strength of SFRC was observed to be in scope of 3 percent somewhere in the range of 7 and 28 days.
- The compressive quality of PPFRC was expanded between 10 percent and 18 percent for 7 and 28 days. Comparing values for Hybrid concrete was expanded by 3 percent to 22 percent for 7 days and 28 days.
- Water absorption consequences of SFRC and hybrid specimen are equivalent to conventional concrete Be that as it may, on account of PPFRC it was 4% expansion the conventional concrete.

A. Annadurai et al (2013) author examined that:

- The utilization of 80% steel fibers and 20 % polypropylene fibers at every volume part gave optimum hardened properties.
- At hybrid fiber volume fraction of 2.0 % with 80%-20% steel – polyolefin mix has increasingly noteworthy effect on mechanical properties.

- The analysis gave the expectation estimations of compressive strength is closer to trial results, 5 rigidity of steel fiber and hybrid fiber strengthened high quality of steel was having mistake rate from 0.76 to 14.26 compare and the deliberate value.

T.S. Thandavamoorthy et al (2014) author noted that:

- The concrete mix with 4% of polypropylene fiber showed that concrete was increasingly elusive and hard to smaller. Increase in compressive strength of SFRC was seen to be in scope of 3% to 60% somewhere in the range of 7 and 28 days, separately.
- The compressive strength of PDFRC was seen to increase between 10% and 18%, separately for 7 to 28 days.
- The quick chloride penetrability test is low for M30 grade concrete and Hybrid specimen as indicated by ASTM 1202 CRITERIA

T.Ch.Madhavi et al (2015) author investigated that:

- A polypropylene fiber reinforced Fly ash concrete is a more reasonable concrete compared with conventional cement.
- Replace the fly ash with cement in concrete reduces a environmental pollution
- Also addition of polypropylene fibers has reduced the chloride attack by 24.6%. The addition of 0.4% polypropylene fibers has reduced the chloride attack by 24.6%.
- Addition of 60% fly ash has demonstrated that the chloride attack was reduced by 40%.

Sagar Sarangi et al (2016) author reported that:

- The test results demonstrates that the weight division of 1% with polypropylene 0.75 substance coir 0.25 combination specimens improves compressive quality and flexural quality as compared and conventional concrete.
- The most extreme compressive strength reaches in the S-3, P 0.75 C 0.25. 75% PP fiber and 25% CC fiber of weight of concrete.
- A flexural quality of HFRC containing weight part of 75% PP fiber and 25% CC fiber is higher than other hybrid fibers.

Hanumesh B et al (2016) author investigated that:

- Based on the experimental investigation the maximum permissible limit for RA with 1% PP fiber is 50% .For 100% RAC with 1% PP fiber volume compressive strength.
- The splitting tensile quality and shear strength increases by 15.68% 34.84% and 38.32% respectively when compared with reference mix proportion.

Nady Mohamed Abd-El-Fattah Morsy et al (2016) author investigated that:

- The concrete along with crimped steel fibers are mixed in the following proportions such as (0.5%, 1%, 1.5% and 2%) were tested at 7 days and 28 days curing under flexural behavior.
- Testing tests were obtained to raise in temperatures up to (500°C for one hour and two hours) and the results were considered and exhibited the redesign level procured due to addition of steel fiber.
- The results reveals that the extension of crimped steel fibers has included to improve the direct tensile strength of the fiber reinforced concrete for both pre and post raised temperature in fire performance testing.

V.Prabhakaran et al (2017) author concluded that:

- The optimum estimations of polypropylene, silica smoke and RHA were resolved for different mix proportion.
- It values are 1% of polypropylene, 7.5% of silica smoke and 15 % of RHA.

- It has with the expansion of fibers, the crack widths are littler at service load if there should arise an occurrence of fiber reinforced concrete beams when contrasted with plain concrete beams.

Sakthi Ganesh G (2017) author concluded that:

- To lessen the measure of cement in the concrete mix, fly ash remains was supplanted in the SCC mix The investigation manages decreasing the concrete substance in the SCC blend with substitution of 15%, 20% and 25% of fly ash.
- The SCC consequently created was oppressed for testing the hardended and durability properties of the concrete. The testing incorporates compressive quality, split tensile test, flexural testing and quick chloride infiltration test.
- The result finishes up, contrasted with the supplanting of fly ash remains with the level of 25% and 20% the concrete mix with supplanting of fly ash with 15% gives more quality and more durable.

Ningaraj C. et al(2017) author concluded that:

- The compressive quality outcomes exhibits HFRC and alccofine give outstandingly high compressive quality when contrasted with plain concrete.
- In water adsorption test expansion of HFRC and alccofine gives lower water ingestion while expansion of just fiber increment the percentage.
- The material which has less water ingestion which demonstrates top notch suggests that is expanding toughness.

Ramesh Kanagavel, et al (2017) author noticed that:

- The workability reduce the fiber content increments, both in mono-fiber and hybrid fiber strengthened concrete mix. Mono CFRC blend performed deficiently with concession sway load. SCHFRC and SCPHFRC specimens confined high effect stacks before hard and fast disappointment.
- The specimen with steel-carbon-PP hybrid fiber exhibited the most raised effect confinement and the best component of increase in the post break block of about 69.8% in the s3c1p1 mix
- The energy required to pass on the essential crack reached out by 5.82 events and the objectives required to finish disappointment expanded by 9.84 events stood out from the conventional concrete at 28 days.

P. Lakshmaian Chowdary et al(2017) author investigated that:

- The experimental program reveal that hardened properties of GPC are improved with the addition of SFRGPC
- It has exhibited an extension of 11 and 14 % in compressive quality and split tensile strength separately compared from GPC and HFRGC has seemed essential addition of 25% in flexural strength appeared differently in relation to GPC.
- Addition of fibres in the GPC mix decrease the water digestion and Sorptivity coefficient values.

Wasim Abbass et al (2018) author noticed that:

- The mixed fibers of strands of 1 % large scale steel fiber and 0.15% micro scale PVA fibers ended up being the best for enhancement in flexural performance of high strength concrete.
- The most intense augment in compressive strength of 2-8% was seen with the addition of hybrid fibers to controlled concrete.

- There is no huge contact of hybridization of compressive strength of concrete. An increase in the flexural strength of mixture with fibers came to up to 150-200% with the various of mix of various fibers as contrast with that of ordinary concrete.

Mohan Xu et al (2018) author noted that:

- The mechanical properties of another sort of hybrid fiber concrete(HFRC) which was fortified by the steel fiber and the ultra-high molecular weight polyethylene (UHMWPE) fiber were inspected
- The characteristics of HFRC is also extended when the UHMWPE fiber are blend dependent on the steel fiber.
- The UHMWPE fiber has continuously clear ramifications for material quality differentiated and polypropylene fiber when it is mixed with the steel fiber reinforced concrete

M. Balasubrahmanyam et al (2018) author noted that:

- The usage of 0.5% steel strands and 0.5% polypropylene fibers at each volume part gave perfect mechanical qualities.
- The compressive strength increased from 5.72%,4.37%, and 7.75% at volume parts of 1% ,1.5%,2% exclusively when differentiated with control mix.
- The split tensile strength ranged running from 7.86%, 5.91%, 3.38% at volume parts of 1%, 1.5%, 2% independently when differentiated and conventional concrete.

Piotr Smarzewski (2018) author investigated that:

- The superior concrete containing basalt/polypropylene fiber blends of 50/50 % and with just polypropylene fiber substance of 0/100 % can be articulated as the most proper mixes to be utilized in HPC for flexural strength.
- Compressive strength of all fiber-fortified HPC diminished by 9% (P1) to 20 % (B2) contrasted and the plain superior concrete.
- In split tensile strength increased in all fiber blends up to 79% for polypropylene fiber-reinforced concrete at the substance of 2%.

P.R.Kannan Rajkumar et al (2018) author found that:

- The river sand was incompletely and completely supplanted (100%) by copper slag in different extents in the solid.
- The concrete is additionally added with fiber so as to improve its hardened properties.
- The compressive test demonstrates that the esteem increments until a specific estimation of stream sand substitution, which in the reason is 50 % any further substitution caused a decrease in the esteem.

Athira Anand (2018) author concluded that:

- The Split elasticity is in like manner improved by the expansion of glass fibers and most extreme is for SGI which is 32.5%.
- Flexural quality is similarly expanded by the expansion of fibers and most noteworthy augmentation is 39.2% acquired first SGI

3. CONCLUSIONS

In light of the above literature survey, manifestly steel fiber (high modulus fiber) which is more superior and stiffer, improves the quality of concrete, while polypropylene fiber (low modulus fiber), has the ability to emphasize delicate cementitious materials and is increasingly adaptable and has the property to hold heat for a delayed time which prompts improved toughness, and strain limit in the post-splitting section and retard early cracks.

Basalt fiber which is high in oxidation opposition and radiation obstruction, fracture energy and abrasion resistance prompts increment in the flexural strength.

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