Fibre Reinforced Concrete

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Abstract- *Concrete plays vital role as a construction material in the world. But the use of concrete as a structural material is limited to certain extent by deficiencies like brittleness, poor tensile strength and poor resistance to impact strength, fatigue, low ductility, and low durability. This is obviously not desirable for any construction material. Thus, concrete requires some form of tensile reinforcement to compensate its brittle behavior and improve its tensile strength and strain capacity to be used in structural applications. In the present scenario the fiber reinforced concrete is not put into use in the construction as for the disadvantages it has got. To overcome the disadvantages and take the profit of its advantages certain experiments are performed to know the characteristics of the FRC. The FRC can give more strength to the building and come overcome the problem of the brittleness caused by the plain concrete. Fiber Reinforced Concrete (FRC) is defined as a composite material essentially consisting of conventional concrete or mortar reinforced by the random dispersal of short, discontinuous, and discrete fine fibers of specific geometry. Fibers are commercially available and manufactured from steel, plastic, glass and other natural materials. This paper presents an overview of the properties of Fiber Reinforced Concrete (FRC), its advantages, its disadvantages, and its applications.*

Keywords- Concrete, Fiber Reinforced Concrete, Physical Properties, Steel Fiber Reinforced Concrete, Conventional Concrete.

I. INTRODUCTION

Concrete is a material that is very strong compression but relatively weak in tension. To compensate to this imbalance in the concretes behavior, an appropriate reinforcement must be cast into the concrete to carry the tensile loads. Two forms of reinforcement commonly used are steel and fiber reinforcement. Fiber reinforced concrete has been used widely throughout western Europe and beyond. Its application in rest of the parts fo the world is so far limited, with industrial floors being the most common application. The lack of formally accepted design standard may be an influence on the situation although calls are being made for clear industrial guidelines. The Concrete Society Technical Report 63 addresses many of the issues. Fiber reinforce concrete is usually Portland cement concrete with metallic or polymer fibers. Fibers are useful in providing greater resistance to plastic shrinkage cracking and service related cracking. Fibers are not intended as primary reinforcing. The fibers are added during concrete production. They are useful in shotcrete and in thin overlays that are not sufficiently thick to accommodate reinforcing bars, and they have good resistance to impact, vibrations and blasts. Their disadvantage of FRC are the reduced workability and possibility of corrosion stains if the fibers are exposed at the surface.

II. ADVANTAGES OF USING FIBRE REINFORCED CONCRETE IN CONSTRUCTION

The most important advantage of FRC is that it helps in prevent in concrete cracking. All other advantages are derivative of this advantage. such as:

- Increased tensile strength in concrete.
- Slightly improved compressive strength.
- Much better bending strength.
- Better waterproofing property.
- Prevention of micro-cracks (depends upon the dimension of fibre used)

III. DISADVANTAGES OF FIBRE RENIFORCED CONCRETE

Using fibers will help in reduce that cracking and slightly increase the stiffness of the concrete. But some disadvantages are:

- Increase in specific gravity of the concrete. This means that the concrete will be heavier than normal concrete in case of some fibers. We are looking at structural concrete so I would avoid considering polystyrene.
- Proportioning the exact amount of fibers in the batch of concrete. Test have shown that a slight variation in fibers creates tremendous changes in concrete strength.
- Higher cost because of its control issues (production issues) as well as the cost of raw material is high.
- Corrosion of steel fibers. We use fibers to increase the tensile strength and stiffness and in order to get

higher performance of concrete we want the fibers to perform well. Corrosion will reduce the performance level.

IV. LITERATURE REVIEW

1. B. Afsin Canbolat et.al (2005):

The authors have reported that:

To simplify the reinforcement requirements in diagonally reinforced RC coupling beams, an alternative design consisting of precast HPFRCC coupling beams with different reinforcement configurations was experimentally investigated. The reinforcement details evaluated in this research project included the use of only distributed horizontal and vertical reinforcement and the use of supplementary diagonal bars without transverse steel reinforcement. The first specimen, used as the control specimen, consisted of an RC coupling beam with diagonal reinforcement designed and detailed according to the ACI 318 Code. In the second specimen, the coupling beam was constructed with a HPFRCC containing PE fibers, and only conventional horizontal and vertical reinforcement was provided. Specimens 3 and 4 were constructed with HPFRCC containing PE and twisted steel fibers, respectively, and supplementary diagonal reinforcement, but no confinement hoops were provided. The structural performance of these new precast HPFRCC coupling beams under reversed cyclic loading demonstrated that a more convenient reinforcement detailing can be used in coupling beams and still maintain adequate seismic behavior. The use of advanced fiber cementitious materials allowed the elimination of the transverse reinforcement typically required around the diagonal bars for confinement, thus simplifying the beam construction process. The test results showed that HPFRCC coupling beams with simplified diagonal reinforcement exhibited higher shear strength and stiffness retention. HPFRCC beams with supplemental diagonal bars reached a drift of at least 4.0% while maintaining approximately 80% of their shear-carrying capacity. Considering the multiple cracking pattern with hairline diagonal cracks up to fiber pullout experienced by the HPFRCC coupling beams, it is clear that HPFRCC material shave superior damage tolerance under large displacement reversals compared with regular concrete.

2. Lijing Wang et.al (2006):

The authors have indicated that:

The addition of hemp fiber into the concrete matrix results in a linear reduction in the specific gravity and the water absorption ratio of the HFRC. The compressive strength, flexural strength, toughness and toughness indices, specific gravity, and water absorption ratio of HFRC are all correlated with aggregate size parameters, fiber factors and matrix initial mechanical properties. These relationships can be presented in simple empirical regression equations in the form of a composite mechanical approach. Different mixing methods affect the mechanical and physical performance of the HFRC composites. Compressive strength of the HFRC is weaker when compared to the conventional concrete regardless of the mixing method used. Wet mix has a more positive influence on the composite's flexural properties (flexural strength, toughness and toughness index) than dry mix method, possibly due to the enhanced bonding between fiber and matrix. These properties make the HFRC more suitable for use in such applications as pavements. Fiber content by weight is the main factor that affects compressive and flexural properties of HFRC, regardless of the mixing method used.

3. D. Soulioti et.al (2009):

The authors have concluded that:

In the present study the influence of steel fibers in the behavior of concrete under bending is discussed. Increased fibre content results in the increase of the maximum load and the fracture toughness of the material. At the same time, the amount of AE activity is proportional to the fiber content and the measured toughness. Analysis of AE parameters reveals that the tensile mode of fracture is dominant for plain concrete. The mode of fracture is changing to shear as the fiber content increases. This demonstrates the reinforcing effect of the fibers against the weak tensile nature of concrete. The study of AE indices implies that the mode of fracture changes during the experiment from tensile (initial stage) to shear (final fracture). This is macroscopically shown by the crack splitting and deflection from parallel to perpendicular direction relatively to the loading axis and the concurrent increase of the fracture process zone with increasing fiber content. As was shown, the acoustic emission technique can be employed for the identification of the fracture mode. The identification of the failure mode is of primary importance as it provides insight for a more suitable design of the reinforcement, in order to withstand the specific stresses. Additionally, as shear cracking follows tensile cracking, crack classification using suitable AE descriptors can assist the evaluation of the severity of the condition. The use of the aforementioned methodology to classify the fracture mode of FRC can also be employed for different types of reinforcement in terms of fiber shape, material and volume content, in order to increase the reinforcing efficiency for optimal structural performance. Furthermore, source location of the AE events via the use of more sensors can experimentally verify the increase of the fracture process zone with increasing reinforcement efficiency.

4. MINGHUI WEI et.al (2009):

The authors have found out that:

The flexure behaviors of five concrete materials (plain concrete, steel fiber reinforced concrete, polymer modified concrete, steel fiber reinforced concrete and polymer modified concrete, and hybrid fiber reinforced concrete), are investigated; with the increase of content of steel fiber, flexure strength of SFRC increase, but there is a threshold content to retard the further increase of the flexure strength, with the polymer solution adding into SFRC, the threshold content can be enhanced and SFRPMC get a higher flexure strength and ductility. Considering performance and economy, HFRC is recommended, preliminary tests show that HFRC may be one of the potential bridge pavement materials.

5. Qinwu Xu et.al (2010):

The authors have reported that:

In this investigation has comprehensively studied the reinforcing effects and mechanisms of four typical fiber types for use in AC mixtures under various environmental temperatures and water freezing–thaw effect. The main conclusions are summarized as follows: Fiber has significantly improved the rutting resistance, fatigue life, and toughness of AC mixtures. Fiber has improved the low-temperature flexural strength and ultimate flexural strain, and split indirect tensile strength. After the water freezing–thaw effect, the split indirect tensile strength of FRAC with polyester and polyacrylinit-rile fibers has only slightly increased, but it has reduced to some extent for the lignin and asbestos fibers; while the tensile strength ratios for FRAC with all these fibers have reduced, one of the important reasons could be due to the increased air voids for more ices to be formed at low temperature. The polymer fibers (polyester and polyacrylonitrile) have greater effects on the rutting resistance, fatigue life and split indirect tensile strength than the lignin and asbestos fibers, and polyacrylonitrile fiber has the greatest effect, which could be primarily due to their greater networking effects dependent on fiber's geometry and physical properties. The lignin and asbestos fibers have greater effects on the flexural strength and ultimate flexural strain than the polymer fibers. This could be due to their greater specific surface areas for greater asphalt absorption and stabiliza-tion as measured by previous research. A fiber content of 0.35% by mass by AC mixture results in the optimum performance outputs of rutting resistance and split indirect tensile strength. However, the effects of fibers under the water freezing–thaw effect do not seem promising, and future research including other experimental test methods (e.g. to measure the fiber-asphalt-aggregate interface bonding strength under the water effect), are needed to further investigate this property. Meanwhile, a greater compaction effort and/or a slightly higher compaction temperature are recommended to reduce the air voids of FRAC for optimizing fiber's reinforcing effects.

6. BENCARDINO et.al (2010):

The authors in the their research have done following observations:

The presence of steel fibers had only a very minor effect on the compressive strength of ordinary concrete. Polypropylene fibers, reduced the compressive strength by about 25% and 35% at 1% and 2% fiber volumes, respectively. Both SFRC and PFRC specimens showed typical tri-linear variation in their load–deflection, load–crack mouth opening and load–crack tip opening displacement curves under flexure. The SFRC specimens showed peak flexural loads of about two to three times that of the PC at 1% and 2% fiber volumes, respectively. The low modulus PFRC specimens, on the other hand, were able to retain the PC peak load values at 1% fiber volume content, but showed a loss of about 40% at 2% fiber volume compared to the peak load of the PC specimens. The low modulus PFRC specimens showed abrupt loss of load capacity immediately after the peak load, the load loss amounting to about 67% and 40% at 1% and 2% fiber volume, respectively. Increasing fiber content increases fracture energy. But the increase is higher in the case of SFRC specimens compared to PFRC specimens.

7. Chaohua Jiang et.al (2014):

The authors stated that:

A series of mechanical properties tests on basalt FRC have been performed in this study. The results obtained show that addition of BF to the concrete leads to a decrease in the workability of concrete. The mechanical performance of basalt FRC is better than that of PP FRC. Compared with the plain samples, concrete reinforced with BF presents high flexural strength and tensile strength. But the compressive strength of concrete reinforced by BF increases slightly at the early age and even decreases at the late age. The length of BF presents a beneficial effect on the mechanical properties of concrete. Compared with the strengths of plain concrete, the compressive, splitting tensile and flexural strengths of concrete reinforced by 12 mm long BF increase by 0.18–4.68%, 14.08– 24.34% and 6.30–9.58%, and the corresponding strengths of FRC with BF of 12 mm in length increase by 0.55–5.72%, 14.96– 25.51% and 7.35–10.37% after 28 days. With the increase of BF content, the improvement of mechanical properties of BF concrete becomes more obvious. And the suitable amount of the admixture of BF is about 0.3% in volume fraction. On the other hand, the addition of BF can improve the toughness index of concrete significantly. And the FRC with BFII of 22 mm in length shows the finest toughness improvement capacity. Furthermore, SEM images of microstructure show that a good bond between BF surface and hydrated cement matrix is obtained in the early age, whereas a debonding phenomenon between cement matrix and BF is observed at 28 days. The MIP results indicate that the paste containing BF presents a higher porosity.

8. Ahmet B. Kizilkanat et.al (2015):

The authors have reported that:

This paper has discussed the mechanical properties and fracture behavior of basalt and glass fiber reinforced concretes. The addition of BF and GF in the concrete mix decreased the workability of concrete. The fiber content greater than 0.25% resulted in slight increase in compressive strength for both basalt and glass fiber. BFRC showed the highest compressive strength of 66.6 MPa at 0.50% inclusion, whereas GFRC showed the highest compressive strength of 67.6 MPa at 0.75% inclusion. In comparison the compressive strength of plain concrete was 63.4 MPa The addition of basalt and glass fibers resulted in an increase in flexural strengths. A slight increase in fracture energy was observed for BF and GF reinforced concrete at the dosage of 0.25%. However significant increase was observed beyond this dosage and fracture energy increased by more than 50% at 1.0% fiber inclusion for both basalt and glass fibers. The KIC and CTODC values of BFRC were higher than that of GFRC for each dosage which indicates that BFRC shows better performance with respect to crack resistance and ductility when compared with the GFRC. In the scope of this study, considering the concrete mix design and fiber contents, the test results showed that BF addition resulted in better workability, higher mechanical properties and enhanced fracture behavior when compared to the GF

9. Alireza Gholamhoseini et.al (2016):

The authors have concluded that:

This paper describes a comprehensive experimental study on sixteen full-scale continuous two span composite slabs with steel decking and a width of 1.2 m and a total length of 6.3 m. Each slab had different types and amount of reinforcement. Shrinkage strains at 98 days of drying in samples made of plain concrete and fiber-reinforced concrete with dosages up to 40 kg/m3 were similar. Cracking due to the shrinkage-induced strains was not observed in the mesh-reinforced or fiber-reinforced composite slabs under their self-weight at 90 days. For the concrete mix used, the mid-span deflection due to concrete shrinkage and creep did not increase significantly after 40 days. No end slip occurred under the serviceability load levels . The failure mode in all slabs was interface slip at the ends. The behavior was ductile according to Eurocode 4. Compared to the slab with plain concrete, the average of deflections at peak load of SFRC composite slabs was 16% higher. SFRC composite slabs with fiber dosages of 20 kg/m3 and 40 kg/m3 performed almost identically to the unreinforced composite slab, in terms of crack control in negative bending moment region. Application of steel fibers for crack control became effective for slab with SFRC with 60 kg/m3 of fiber, which showed a very significant improvement in crack control of the mesh-reinforced slabs.

10. E.ARUNAKANTHI et.al (2016):

The authors have concluded that:

In compressive strength, flexural strength and split tensile strength, the addition of Steel fiber the strength is increasing linearly, but in glass fiber up to 1% it is increasing and from 2% it is decreasing. It is concluded that the strength is increasing while increasing the percentage of steel fiber. But in the case of glass fibers, the strength is increasing up to 1%. After 1% the strength is reducing. Finally concluded that glass fiber can be add up to the 1%.

11. M. SINGH et.al (2017):

The authors have stated that:

The study in this paper presents the experimental investigation on the flexure behavior of UHPFRC (Ultra high performance fiber reinforced concrete) beams reinforced with conventional steel bar reinforcement. All the tested beams exhibited ductile failure and the failure is due to the rupture of steel bar reinforcement. The steel fibers effectively resisted the widening of the cracks and lead to the increased load carrying capacity even after the steel bars are yielded. To predict the flexural behavior of the UHPFRC beams, the numerical models were developed where concrete damaged plasticity model (CDP) is adapted to simulate the material behavior of

UHPFRC. The material properties are extracted from material tests conducted on UHPFRC, which served as critical input for CDP model. The results obtained from the numerical analysis of the beams are validated with experimental data conducted in this study. The numerically obtained load-deflection behavior agrees well with the experimental results for all beams. The moment capacities predicted by the numerical models vary by 5% when compared to the experimental results. The pre and post peak load-displacement behavior is well captured by the numerical models. The results show that the calibrated CDP model can be used to predict the overall load-displacement behavior of the reinforced UHPFRC beams when the material properties are obtained from material tests.

12. F.Ortiz Navas et.al (2018):

The authors found that:

In this experiment sixteen full-scale beams were tested by applying a concentrated load at the mid-span. The main investigated parameters were the influence of macro-synthetic fibers (10 kg/m3 ,Vf ¼ 1:1%) on shear resistance, and its effect on the MOF. The beams tested by Bresler Scordelis at the University of Berkeley in the early 1960s inspired the geometry of the present beams, but with certain material differences. The inclusion of macro-synthetic fibers in reinforced concrete beams w/o transverse reinforcement is unable to change the MOF, but can change MOF performance by presenting critical diagonal crack openings upon failure within a range of several millimetres, plus less fragile behavior. The macro-synthetic fibers added to the beams w/o transverse reinforcement achieved a similar response in some cases to those observed in the reinforced concrete beams with transverse reinforcement. The macro-synthetic FRC beams, used in combination with transverse reinforcement, achieved a higher ultimate load versus the beams w/o fibers. A synergy effect in shear strength terms between the fibers and transverse reinforcement was observed in two of the four beam series, which evidently shows that a synergy does not always occur. In some cases, even yielding longitudinal reinforcement in tension was achieved. Macro-synthetic fibers can serve as an effective mechanism of shear transfer.

V. CONCLUSION

The present research work leaves a wide scope for future investigators to explore many other aspects of such hybrid composites. Some recommendations for future research include:

- The other properties of composites such as moisture absorption, fatigue and tribological behavior may be determined using extensive experimentation.
- The experiments can be extended by adding other potential natural fibers, by changing the fiber orientation and fiber content and their mechanical and machining characteristics may be analyzed .
- The experiments can be extended by increasing the number of machining parameters, such as tool geometry, tool materials, etc.
- The experiments can be repeated by using different tool inserts with wider geometries.
- The experiments can be extended to other machining processes, such as milling, reaming etc.
- This experiments can be extended to study the effectiveness of copper slag steel fiber reinforced concrete on reinforced flexural members.
- The effectiveness of copper slag concrete on columns for axial compression and bending can be studied further.
- Utilization of copper slag on high strength concrete beams for shear, torsion and cyclic loads can be carried out.
- Strength and durability properties of copper slag concrete by adding non metallic and organic fibers can be studied.

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