FIBRE UTILIZATION IN CONCRETE AND ITS EFFECT: REVIEW

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Abstract:*Concrete has the main role in any construction work in all over the world. We don't aspect any civil construction without concrete. But in concrete, some deficiencies are found like brittleness, tensile strength, and poor resistance to impact strength, fatigue, low density, and durability. And all the deficiencies to reduce and improve the quality of concrete we added some improving material like different types of fibre that improving the quality of the concrete and provide good strength and many other properties. Concrete used as a binding material in present condition in the entire world. Concrete is a very heterogeneous composite material. It is a composite material, where coarse and fine aggregates are filler material, and cement paste is binding material. The maximum properties of concrete and workability of concrete depend on the aggregate. The characteristic of concrete should measure on the relative basis, and degree of quality must maintain for construction purpose. Concrete should be durable to work satisfactorily under different condition, which shall give it protection from disintegration in severe exposure condition. Water tightness is essential for a hydraulic structure, but strength and rigidity are the primary structural requisite for the building. Concrete is made up of fine aggregate (sand), coarse aggregate (gravel or crushed stones etc.), cement and water to make a hardened paste. These material are mixed in proper proportion to make a plastic mass which can be moulded into any predefined shape as per IS standard. After hydration of cement by water, the concrete shows hardness as that of stone and provide the greater strength of the member. Due to this concrete plays a key role in the construction of building elements.*

Keywords: Fiber; Concrete; Compressive strength; Workability

1. INTRODUCTION

Today the civil engineering industries grow very rapidly the use of new material of construction is a very important need because it saves our environment and natural resources. Most of the construction in now days are done with cement, sand aggregate and water mix commonly called concrete. Concrete is a versatile material it has very important properties which makes it the best constructional material used for making any structure which possesses enough strength. The best improvement achieved by the addition of fibre to concrete, there are several uses and benefits. Mostly fibre used in many large projects like the construction of industrial floors, pavements, highway-overlay, etc. The principal fibres in common commercial use for civil engineering applications include steel, glass and carbon. Fibres in the form of the matalso used in the development of high-performance structural composite. Different types of fibre used in the country and many advantages to giving the concrete like the light weight of building a structure or other civil structure. Thereby reducing the overall cost of construction and also reducing the dead load. Different type of fibre used in concrete these are glass fibre, steel fibre, synthetic fibre, and natural fibre which affect the properties of concretes like increasing strength, geometries, distribution, orientation and densities of concrete. Also,fibrecontrols the property of concrete like cracking due to plastic shrinkage and to drying shrinkage. They also reduce the permeability of concrete. Sometimes fibres do not increase the flexural strength of concrete and cannot replace moment resisting or structural steel reinforcement. The amount of fibre added to concrete mix percentage of the total volume of the concrete and fibre termed volume fraction (v.f.) ranges from 0.1 to 3%. The aspect ratio calculated by dividing fibre length (l) by its diameter (d). If the fibre's modulus of elasticity is higher than the matrix (concrete or mortar binder), which helps to increase the tensile strength of the material. Fibre addition in concrete increases toughness and strain at peak stress of concrete.FRC concretes are used for numerous applications which resisttension, flexure, shear, fatigue, impact etc., hence, the studies related to FRC subjected to impact, flexure, shear, tension and compression are discussed.Three types of fibres – Polyvinyl alcohol (PVA) micro fibres, PVA fibres and steel fibres – were used in different combinations as reinforcement for the mortar matrix. It has been concluded that the cement mortar reinforced with 1.5 percent steel (6mm in length) and 0.5 percent PVA fibres (12mm in length) showed a flexural strain hardening behaviour accompanied by multiple cracking when a large amount of cement in the composite (about 50 percent) was replaced by fly ash. The result was a composite with high flexural strength, high flexural toughness and high ductility.

2. TYPES OF FIBRE CONCRETE

2.1 self-compacting steel fibre reinforced concrete

Self-compacting concrete (SCC) defined as a flowing concrete mixture which can consolidate under its weight. This type of concrete is required mainly in industrial construction, as other than this concrete the main problem is placing the concrete at congested zone is difficult. The flowing nature of SCC makes it suitable for placing it in difficult conditions. Self-compacting concrete widely used in the long distance travelled by the concrete. In this type of concrete, we don't require vibrator, and the main thing is no skilled labours required. This type of concrete is highly fluidity and high workability. Therefore it is used in industrial construction to overcome placing difficulty.

2.2 Glass fibre concrete

In the modern age, many types of fibre invented like fly ash, coconut fibre used in the concrete. Then the glass fibre is used in the concrete, and these provide a good result after the testing of the concrete. The main aim of the study is to find the effect of glass fibre in the concrete. Glass fibre provides good tensile strength, and fire resistance means reducing the loss of damage during fire resistance. Light in weight, extremely strong, and robust material. Glass fibre concrete is good strength in compression as well as tension.

2.3 Plastic fibre

In the world, the most important thing in the civil construction is the concrete. Without concrete, we don't think about the construction work. The common material used in concrete are cement aggregate, sand and water. Now a day's global consumption of natural sand that obtain by the river but river sand is also limited. Therefore these things are available in a certain limit. And we required new material used in the concrete, but they don't bad effect on the property of concrete. Plastic is waste material, and it is non-biodegradable and polluted the environment. These also reduce the production (agriculture) of land. Therefore invented the plastic fibre. Manufactured sand replaces natural sand,and plastic fibre is mix with fixed (0.5%) percentage of cement. Inplastic fibre, we used waste plastic water bottle having low density polyethene. Generally, in plastic fibre, we used cutting the waste plastic bottle into the laminar shaped fibre. Having thickness of fibre material is varying from 0.125 to 0.150mm. Plastic fibre used 0.5% by weight of cement addedto the concrete.

2.4 Carbon Fiber Reinforced Concrete

Concrete containing short carbon fibres (0.2 – 0.5 vol. %) was found to be an intrinsically smart concrete that can sense elastic and inelastic deformation, as well as fracture. The signal provided is the change in electrical resistance, which is reversible for elastic deformation and irreversible for inelastic deformation and fracture. The presence of electrically conducting short fibres is necessary for the concrete to sense elastic or inelastic deformation, but the sensing of fracture does not require fibres. The fibres serve to bridge the cracks and provide a conduction path. The increase in resistance is due to conducting fibre pullout in the elastic regime, conducting fibre breakage in the inelastic regime, and crack propagation at fracture (Chen et al. 1995).

2.5Polypropylene Fibers

Now at the modern age, we required good compressive strength, tensile strength and as well as workability property of concrete. But these property is achieved from the normal green concrete is not possible. And it is very challenging and difficult task in the civil construction. But we required the high strength of concrete and workability of concrete by addition of some material or content they provide these properties. The influence of polypropylene fibres was studied by Bagherzadeh et al. (2012) with different proportioning and fibre length to improve the performance characteristics of the lightweight cement (LWC) composites. Fibresused in the concrete two different lengths (6 mm and 12 mm)andfibre proportions may vary from 0.2% and 0.35% by cement weight in the concrete. After 7- and 28-day of curing of the Hardened concrete properties like compressive strength, splitting tensile strength, flexural strength, water absorption, and shrinkage were evaluated. From the addition of Fiber was seen to increase the physical and mechanical properties of lightweight concrete. Compared to un-reinforced LWC, polypropylene (PP) reinforced LWC with fibre proportioning 0.35% and 12 mm fibre length, caused 30.1% increase in the flexural strength and 27% increase in the splitting tensile strength.

3. LITERATURE REVIEW

Yogendran et al. (1987), have studied extensively High Strength Concreteusing Silica Fume with no air entrainment to achieve compressive strength in the range of 50 to 70MPa in which cement was replaced by silica fume (0 to 30 percent by weight). The efficiency of silica fume in improving the properties of concrete was compared at medium and very low water cementitious ratios. Concretes with water cementitious ratios of 0.34 and 0.28 with and without a superplasticizer, at a constant slump (50 mm) and with varying slump were also investigated. It has been concluded that for concretes with 5 to 30 percent replacement of cement by silica fume and a constant slump of 50 mm there was no increase in water demand up to 5 percent replacement. The water required to maintain a constant slump, however, increased linearly as the percentage of silica fume replacement increased from 10 to 30 percent.A 5 percent replacement produced the highest compressive strength at 7 and 28 days.Replacement of 10 percent and 15 percent produced strength equal to the control mix at 7 and 28 days. Replacement levels of 25 percent and 30 percent produced lower strengths at all test ages.

Gopalaratnam et al. (1986), have discussed the effect of strain rate on theflexural behaviour of unreinforced matrix and three different fibre reinforced concrete(FRC) mixes. The objective was to study the properties of Steel Fibre ReinforcedConcrete subjected to Impact Loading. A Conventional Charpy Impact Machine wasmodified and instrumented to facilitate tests on FRC Specimens at different impactvelocities. Smooth brass coated steel fibres of length 25.4 mm and diameter 0.41mmwas used. Three different volume fractions of fibres 0.5, 1.0 and 1.5 were used. The testresults have shown that the inclusion of fibres in the matrix enhances the compressivestrength and the corresponding strains. Plain matrix had a compressive strength of30.44 MPa while 1.5 percent FRC had strength of 40.98 MPa. The value of strain atpeak stress for the 1.5 percent FRC specimens was 3750 micro strains compared to2700 micro strains for the unreinforced matrix.

Barr (1987), has studied the shear performance of fibre-reinforced concrete(FRC) materials. The performance of FRC materials has been studied and characterizedby two-fracture parameters - fracture toughness (resistance to cracking) and toughnessindex (quantifies the post first crack toughness). Three types of fibres (steel,polypropylene and glass fibre) have been used to study the shear performance of fibrereinforcedconcrete specimens using double-notched specimens with conventional steelstirrups. It has been found that the shear strength of steel FRC increased by the additionof fibres (by weight). The test results have shown that the inclusion of fibres in thematrix enhances the shear strength of the concrete. The matrix had shear strength of8 MPa for 1 percent addition while 10 MPa for 4 percent addition of fibres.

Swamy et al. (1987), have investigated the influence of short steel fibres, alone or in conjunction with conventional steel stirrups on shear transfer in concrete. The main variables investigated in the research include fibre content by volume, amount of stirrups and the type of concrete. Only one type of fibre 0.50 mm diameter and 50 mm length round, fully crimped fibres and two types of stirrup reinforcement, mild steel and high tensile ribbed steel was used. The study was done using fibre volume of 0 percent to 1.2 percent and the type of concrete was normal weight concrete and lightweight concrete. The results show that the crack width varied from 0.15 mm to 0.53 mm with about 75 percent of the values in the range of 0.15 mm to 0.30 mm. Fibres increased the residual shear transfer strength of cracked specimens and this increased with increasing fibre volume.

Gopalaratnam et al. (1991), have studied the fracture toughness of fibre reinforced concrete. The research included the parameters, such as size, fibre volume content, fibre type and the effect of notch. Two types of steel fibres crimped steel and hooked end steel and fibrillated polypropylene were used as reinforcement. Two types of volume fractions were used for each of the mixes (0.5 and 1.0 percent for the steel fibre mixes and 0.1 and 0.5 percent for polypropylene mixes). The concrete mixes were designed for a compressive strength of 34.48 to 41.37 MPa.

Mariano Valle et al. **(**1993), have studied shear strength and ductility properties of fibre reinforced high strength concrete under direct shear. Both experimental and modelling studies were performed. The direct shear transfer behaviour of fibre reinforced high strength concrete was investigated on rectangular notched specimens. Two types of fibre, polypropylene and steel fibres, in conjunction with or without conventional steel stirrups, were used. The concrete strength was identified as Normal Strength Concrete (NC) 31 MPa, Steel fibre reinforced normal strength concrete (SNC) 29 MPa, Polypropylene fibre reinforced normal strength concrete (PNC) 28 MPa, High Strength Concrete (HC) 62MPa, Steel fibre reinforced high strength concrete (SHC) 80MPa and Polypropylene fibre reinforced high strength concrete (PHC) 62MPa. It has been reported that higher shear strength values are obtained with the high strength concrete specimens (M60 – M80) reinforced with steel fibres alone compared to the Normal Strength concrete specimens (M25 – M35). Greater shear strength increases were found with fibre reinforced high strength concrete specimens (60 percent with steel and 17 percent with polypropylene fibres) than with fibre reinforced normal strength concrete specimens (36 percent with steel fibres and no increase with polypropylene), compared to the strength of their respective unreinforced plain concrete specimens.

Ali Khaloo et al. (1997), have done critical comparison of strength and ductility properties of steel fibre reinforced low to high strength concrete under direct shear. The concrete strength is identified as Low Strength Concrete (LC) 28MPa, Normal Strength Concrete (NC) 42MPa, medium strength concrete (MC) 56MPa and High Strength Concrete (HC) 70 MPa. It has been reported that concrete of higher strength reinforced with fibre provided greater shear strength increase than those of lower strength specimens compared to the strength of their respective unreinforced plain concrete specimens. For specimens with one percent fibre volume and aspect ratio of 58, the percentage increase was 39, 47, 59 and 86 corresponding to LC, NC, MC and HC specimens, respectively. For plain specimens, failure occurred in a very brittle manner with limited warning before collapse, and the SFRC specimens manifested a relatively ductile type of failure.

Mirsayah Amir et al. (2002), have studied the shear behaviour of fibre reinforced concrete using direct shear tests. Two types of fibres were used; one with flattened ends and a circular cross section (FE) and the other with a crimped geometry and a crescent cross section (CR). Shear tests were conducted using JSCESF6 standard test method. Among the two fibres, the FE fibres were seen to be more effective than the CR fibre. The comparison of shear toughness as function of shear strain for FE fibres was found to be 1620 Nm whereas for CE fibres it was found to be 1350 Nm for 1 percent fibre volume fraction.

Senthil Kumaran (2012), has studied the development of a ―New Generation Rubberised Concrete (NGRC) and evaluation of its basic engineering properties. The research focuses on determining the correct proportioning of the tyre fibres that has to be added to the concrete mix design to get optimum properties of concrete and fixingup the exact dimensions of the tyre fibre that is most suitable for the concrete mix because the length of the fibre, the diameter of the holes and the number of holes in them play an important role in determining the properties of the concrete like toughness, durability and deformation. The mechanical properties such as split tension, flexure and direct shear have been studied on NGRC and Control Specimen (CS). The standard cylindrical moulds 150mm diameter and 300mm height were made with two slits, eachof thickness 3mm to study the shear strength of concrete. The distance between the slits were 30mm, 60mm, 90mm, 120mm and 150mm. The results show that, in both cases of CS and NGRC, the shear stress reduces gradually with increase in the shear slit distance. It was also observed that from 30mm slit to 60mm slit the reduction in shear stress was around 68% for NGRC and CS. For 30mm to 90mm slit there is a major variation in the shear stress value when compared to CS and NGRC. But for 120mm to 150mm slit the shear stress values of CS and NGRC are almost equal.

Takashi Horiguchi et al. (1997), have studied the fracture toughness of fibre reinforced concrete in compression as well as in flexure and have used four different types of steel fibre with two types of polyvinyl alcohol (PVA). The different types of steel fibre used were hooked fibre (Aspect ratio 50, 37.5 and 75) and straight fibre (Aspect ratio 37.5). The two types of PVA fibres used were straight with aspect ratios 42.9 and 71.4. The study focused on the hybrid effects of fracture toughness in compression as well as in flexure by mixing the steel and PVA fibre. The different types of concrete studied were steel fibre reinforced concrete (SFRC), PVA fibre reinforced concrete (VFRC) and hybrid fibre reinforced concrete (HFRC). It has been reported that the compressive toughness of SFRC, VFRC and HFRC increased in proportion to the volume fraction of fibre. The toughness of HFRC showed the highest value by adding 1.5 percent fibres, while it showed a mean value between that of SFRC and VFRC at 1.0 percent fibre content. This has indicated that the hybrid effect on compressive toughness due to improvement of brittle property when two different fibres mixing together is in good composition.

4. CONCLUDING REMARKS

Generally found concrete is weak in tension and brittle. In the addition of different types of fibre, we got the better result. They also reduce the crack developed in the structure. And also increase the load capacity. The benefit occurring is enhanced crack resistance and ductility. Fibre made of steel, glass, polypropylene, etc., are generally used in concrete. Fibre helps to load internal microcracks. In overallfibre provide an improvement in tensile strength, fatigue characteristics, durability, shrinkage characteristics, cavitation, impact, and serviceability and erosion resistance of concrete. They also provide the property like fire resistance. The literature reviewed has indicated that cracking in concrete is a gradual,multi-scale process, occurring at both the micro and the macro levels.The enhancement of tensile strength by the introduction of different types of fibres (in hybrid form) into the concrete has been established from the literature survey. When single macro fibres are used it helped in the post cracking behavior of concrete. When micro fibres are added it helped in pre cracking behavior. The combination of these two types of fibres enhanced the behavior both in the pre cracking as well as post cracking stages of concrete. The flexural strength of concrete is studied using various fibre combinations and synergy is also observed in most combinations. The fibres used were mico fibre and a macro fibre. The mico fibre was Polypropylene, PVA, polyester, polyethylene or steel. The macro fibre was a steel fibre. Hence studies on different micro fibres such as steel and polyethylene for controlling the micro crack and hooked end steel fibres for controlling the macro cracks are limited. The direct tensile strength of HyFRC is also limited. The studies used were investigated with steel fibres of various geometries and hence studies related to use of synthetic micro fibre, steel micro fibre and steel macro fibre is also limited. Up to date studies on the development of HyFRC with High Performance Concrete using micro steel, polyethylene and macro steel only limited and only little work has been done so far. The direct shear strength of concrete is studied using notched cylindrical specimens with a single type of fibre. The study includes fibres in conjunction with steel stirrups as reinforcement. Hence combining various types of fibres in hybrid form to study the direct shear is limited. The high performance concrete played a key role with the above combinations. In structures, the tensile cracking is seen in pure flexure members and combination of flexure and shear in members. Studies on shear behavior of the High Performance concrete together with fibres are scanty and limited and warrant further research in this direction.Therefore, there is ample scope to introduce all these fibres in concrete and it is needed to investigate further important properties for the development of High Performance Concrete for different grades of concrete which can be used in actual practice.

5. REFERENCES

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