Effect Of Chopped Glass Fiber Tests On The Strength Of Concrete Tiles

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Abstract- *The effect of glass fiber on flexural strength, split-tensile strength and compressive strength was studied for different fiber content on M-20 grade concrete designed as per IS 10262.The maximum size of aggregates used was 20mm. To study the effect on compressive strength, flexural strength, split-tensile strength 6 cubes, 6 prisms and 6 cylinders were casted and tested. After that a practical application of GFRC in the form of cement concrete tiles was taken into consideration and no special technique was used to produce this tiles. The thickness of the tiles was 20mm and maximum size of aggregates used was 8mm.The water cement ratio was kept consistent and the admixture content was varied from 0.8 to 1.5 percent to maintain slump in between 50mm to 100mm.The mix proportion used was 1:1.78:2.66.The size of short fibers used was 30mm and the glass fibers were alkali resistant. The effect of this short fiber on wet transverse strength, compressive strength and water absorption was carried out. Six full sized tiles 400mm*400mm*20mm were tested and the results recorded. Pulse velocity tests were also conducted.*

Keywords- flexural strength, split tensile strength, GFRC, water ratio, transverse strength, compressive strength

I. INTRODUCTION

One of the most important building materials is concrete and its use has been ever increasing in the entire world. The reasons being that it is relatively cheap and its constituents are easily available, and has usability in wide range of civil infrastructure works. However concrete has certain disadvantages like brittleness and poor resistance to crack opening and spread. Concrete is brittle by nature and possess very low tensile strength and therefore fibers are used in one form or another to increase its tensile strength and decrease the brittle behaviour. With time a lot of experiments have been done to enhance the properties of concrete both in fresh state as well as hardened state. The basic materials remain the same but super plasticizers, admixtures, micro fillers are also being used to get the desired properties like workability, Increase or decrease in setting time and higher compressive strength. Fibers which are applied for structural concretes are classified according to their material as Steel fibers, Alkali resistant Glass fibers (AR), Synthetic fibers, Carbon, pitch and polyacrylonitrile (PAN) fibers.

GLASS FIBER REINFORCED CONCRETE

Glass fiber reinforced concrete (GFRC) is a cementitous composite product reinforced with discrete glass fibers of varying length and size. The glass fiber used is alkaline resistant as glass fiber are susceptible to alkali which decreases the durability of GFRC. Glass strands are utilized for the most part for outside claddings, veneer plates and different components where their reinforcing impacts are required during construction. GFRC is stiff in fresh state has lower slump and hence less workable, therefore water reducing admixtures are used. Further the properties of GFRC depend on various parameters like method of producing the product. It can be done by various methods like spraying, casting, extrusion techniques etc. Cement type is also found to have considerable effect on the GFRC. The length of the fiber, sand/filler type, cement ratio methods and duration of curing also effect the properties of GFRC

Application
The main area of FRC applications are as follows

- Runway, Aircraft Parking and Pavements.
- Tunnel lining and slope stabilization
- Blast Resistant structures.
- Thin Shell, Walls, Pipes, and Manholes.
- Dams and Hydraulic Structure.
- Different Applications include machine tool and instrument frames, lighting poles, water and oil tanks and concrete repairs.

PRESENT INVESTIGATION

The purpose of this research is to explore the compressive strength, split-tensile strength and flexural strength properties of concrete reinforced with short discrete fibers. The study was carried out on M-20 grade concrete the size of glass fibers used was 30mm and the fiber content was varied from 0% to 0.3% of the total weight of concrete. In studying the above three properties no admixture was used.

Also the effect of glass fiber on cement and concrete tiles was studied whose fiber content was varied from 0% to 0.7% of the total weight of concrete. Cement and concrete are heavy duty tiles which are used at various places and are of practical use.

II. REVIEW OF LITERATURE

Concrete which is one of the most important construction material and is brittle in nature with very good compressive strength but weak in tension and flexure as a result concept of fiber reinforced concrete has developed. The term fiber-reinforced concrete (FRC) is defined by AC1 116R, Cement and Concrete Terminology, as concrete containing dispersed randomly oriented fibers. With time a lot of fibers have been used in order to improve the properties of concrete and even waste materials like fly ash, silica fumes have also been used. The concept of using natural fibers has also evolved but its durability remains questionable. The work done by using different fibers, waste materials and their effects are discussed below in a sequential manner.

Use of fibers in a brittle is not a new concept, the Egyptians used animal hairs, straw to reinforce mud bricks and walls in houses, around 1500 B.C. (Balaguru et al, 1992). Ronald F. Zollo presented a report on fiber reinforced concrete in which he had mentioned about 30 years of development and research in this filed. In the report it is claimed that the work on FRC started around 1960.Since than a lot of work has been done on FRC using different methods of production as well as different types of fiber, size of fiber, orientation and distribution. American Concrete Institute (ACI) Committee 544 divided FRC broadly into four categories based on fiber material type. SFRC, steel fiber FRC; GFRC, glass fiber FRC; SNFRC, synthetic fiber FRC including carbon fibers; and NFRC, for natural fiber FRC. The idea of fiber support has been produced in current times and weak cement based brittle matrix was strengthened with asbestos filaments when in around 1900 the alleged Hatschek innovation was created for creation of plates for material, funnels, and so forth. Later, glass fibers were proposed for fortification of concrete glue and mortar by Biryukovichs. The ordinary E-glass fibers are not durable and resistant in highly alkaline Portland cement paste.- Majumdar and Ryder invented Alkali Resistant glass fibers by adding Zircon oxide(ZrO_2). Romualdi and his co-authors published important influences of the use of steel fiber in concrete which lead the development of steel fiber reinforced cements (SFRC). Over the last 40 years a lot has been done to develop the cement based matrices. The fundamental reason for short scattered filaments is to control the break opening and proliferation. Basic groups of fibers applied for structural concretes and classified according to their material are Brandt:

Steel fibers are most important for structural concrete. Studies also reveal that hooks at the end of the steel fibers, shape, size etc may improve the fiber matrix bond and also the efficiency may be increased. It has also been observed that due to the presence of fibers large cracks are replaced with dense system of micro-cracks. Opening, propagation of micro cracks are controlled by fine fibers as they are densely dispersed in cement matrix. Longer fibers 50 or 80 mm can increase the final strength of FRC and may help in controlling large cracks. The under load behaviour of a SFRC is completely modified with the increase of fiber volume and efficiency.

Not only steel fibers PVA fibers either monofilament or fibrillated polypropylene size varying 10 mm to 80 mm diameter varying 0.5 mm to 1.5 mm are used in high volumes (0.5-2%),it can increase the impact and fatigue strength as well as the strength and toughness of the structural concrete elements. Polypropylene fibers are low modulus and can serve two different purposes depending on the amount used in concrete. On the off case that utilized as a part of little sum (up to 1.0 kg/m3) it can control the shrinkage splitting of solid in couple of first hours of setting. During that period, the Young's modulus of cement is like that of the strands, Ramakrishna et al. The polypropylene fibers can also serve in case of high temperature and fire and as such are used in concrete walls of apartment building, what happens is that these fibers melt and channels are created which helps in releasing the internal pressure there by delaying the destruction of concrete.

Carbon fiber reinforced mortar (CFRM) and carbon fiber reinforced cement (CFRC) are composites that have high flexural quality and durability and low drying shrinkage, notwithstanding this they have great electrical properties, for example, voltage-touchy impact. Ease pitch carbon filaments is satisfactory for scaffolds, other structural designing structures furthermore for cladding for structures, Kucharska and Brandt. In the districts with Corrosive impact of marine climate and solid winds (e.g. in Japan) CFRC is utilized as a part of scaffold auxiliary components for preferred toughness over it would be conceivable utilizing steel filaments.

Fiber-reinforced polymer (FRP) bars can be used to replace steel reinforcement conventional steel has the inherent problem of corrosion as a result of which it undergoes expansion and concrete cracking may occur; therefore FRP rebar may be used as an alternate. The use of this fibers excludes the problem of corrosion and increases the ductility of the FRP- reinforced concrete beams but the load deflection was found to be higher.(Mohamed S. Issa, Ibrahim M.Metwally, Sherif M. Elzeiny 2010).

SIFCON (slurry penetrated fiber cement) is an in number composite in which a high volume of steel filaments is utilized by unique innovation. Strands are preplaced in a mold and the fiber framework got is invaded by cement slurry. Fiber volume may achieve 8–12%, occasionally significantly higher, and filaments 100–200 mm long may be utilized. The concrete slurry is loaded with fine sand, small scale total and exceptional added substances like fly-ash and silica fumes. The high smoothness (low consistency) of the slurry is vital for satisfactory infiltration of the thick fiber frameworks in a mold. High-quality and resistance against nearby effects and infiltration of shots describe the components made with SIFCON. At the point when rather than single filaments the woven or plaited mats are utilized, then the name SIMCON (slurry penetrated mat cement) is utilized. The fundamental uses of both materials are overwhelming obligation asphalts, hostile to terrorist shields, dividers in bank treasuries, and so forth. Where extra cost of materials and unique innovation are work.

Analytical Approach

One of the important applications of fiber reinforced concrete involves making earthquake resistant structures. Not only earthquakes, most of the unanticipated loadings are cyclic in nature. The behaviour of fiber reinforced concrete beams under cyclic loading which simulates seismic motion is important from study point. The critical seismic design parameter called cumulative ductility Indicator was proposed by Banon et al (1981).

Roufail and Meyer (1987) proposed some analytical modeling of hysteretic behaviour of reinforced concrete structures. Measures of stiffness degradation have been considered as damage indicators: But in the equation used, the effect of repeated cyclic loading was not considered.

Kratzig et al (1989) proposed a model to evaluate the damage index in reinforced concrete under cyclic loading. The proposed damage index was based on the hysteric energy absorbed by a member. The first loading cycle at given amplitude is termed as primary half cycle, with subsequent cycle at the same or smaller amplitudes termed as follows. Then, the damage index for the positive half cycle was defined. A similar index was defined for a negative cycle, the overall damage index was calculated.

Wang and Shah (1987) proposed a reinforced concrete hysteric model on the damage concept. The proposed damage was a simple one in which the rate of accumulation of damage is assumed proportional to the damage already incurred.

An extensive study of literature suggests that glass fibers may enhance the toughness, flexural strength, tensile strength, impact strength, fatigue performance as well as the failure mode of the concrete when compared to plain concrete. The fire resistance of glass fiber reinforced concrete is also good.

III. MATERIAL AND METHODOLOGY

Cement:

Portland slag cement (PSC) – 43 grade (Kornak Cement) was used for the experimental programme. It was tested for its physical properties in accordance with IS standards

Glass Fiber:

Glass fiber also known as fiberglass is made from extremely fine fibers of glass. It is a light weight, extremely strong and a robust material. Glass fibers are relatively less stiff and made from relatively less expensive material as compared to carbon fibers It is less brittle and also has lower strength than carbon fibers. There are various types of glass fibers:

In our case AR-glass fibers were used. The glass fibers used had a density of 2.7 gm/cm3, tensile strength 1700 MPa and Young's Modulus 72GPa.

Coarse aggregate:

The aggregates the vast majority of which are held on 4.75mm IS sieve and contains just that a lot of fine material as is allowed by the code specifications are termed as coarse aggregates. The coarse aggregates may be crushed gravel or stone obtained by the crushing of gravel or hard stone; uncrushed gravel or stone resulting from natural disintegration of rock and partially crushed gravel or stone obtained as a product of the blending of the naturally disintegrated and crushed aggregates. In our case crushed stone was used with a nominal maximum size of 20 mm and specific gravity of 2.78.

Admixture:

Admixtures are the chemical compounds that are used in concrete other than hydraulic cement (OPC), water and aggregates, and can also be called as mineral additives that are added to the concrete mix just before or during blending to adjust one or more of the particular properties of the concrete in the fresh or hardened state. The utilization of admixture is necessary to offer a change which is not financially achievable by changing the extents of water, cement and though not influencing the performance and durability of the concrete. Usually used admixtures are accelerating admixtures, retarding admixture, air-entraining admixtures and water-reducing admixture. In our case a water reducing admixture was used to obtain the desire workability as with increase in fiber content the mixture was becoming stiffer.

CASTING, CURING AND TESTING

The tiles were prepared as per the guidelines of IS 1237:2012. The size chosen was one of the standard sizes mentioned in the code. The size was 400mm*400mm*20mm.The tiles were prepared from a mixture of Portland slag cement, natural aggregates and after casting this tiles were vibrated. The tiles were single layered and outmost care was taken to prepare them so that thickest and thinnest tile in the sample when compared did not exceed 10% of the minimum thickness. The mix was prepared by machine and then the mix prepared was poured in the moulds one at a time and then first they were hand compacted after that vibrated on the vibrator table. The surface finishing was done by using a finishing trowel. After pouring in the moulds and compacting on the vibrator table the moulds were put down on the surface and allowed to set for 24hrs.The mould for casting tiles is shown in fig.1.

Fig.1: Mould for casting of tiles

A significant part of the physical properties of cement rely on upon the degree of hydration of bond and the resultant microstructure of the hydrated concrete. As a result of hydration a random three dimensional structure is gradually formed which fills the space occupied by water. The hardened cement paste has a porous structure and the pores can be divided into two categories as gel pores and capillary pores. Hydration of cement takes place only when the capillary pores remain saturated. Curing is necessary to make the concrete more durable, strong, impermeable and resistant to abrasion and frost. Curing is done by spraying water or pond curing or keeping them packed under moist gunny bags so as to prevent the loss of moisture from the surface and inside. Curing starts as soon as the concrete reaches its final set. It is generally recommended to do curing for at least 14 days to attain at least 90% of the expected strength. In our case pond curing method was used for all specimens including the tiles.

IV. RESULTS AND DISCUSSION

Compressive Strength

The compressive strength was studied and the values are shown in Table-1. It shows the data of 7 and 28 days obtained compressive strength. Table 1 gives the compressive strength of concrete with maximum nominal size of aggregates 20mm.The compressive strength was also plotted Fig.2. From the graph it is observed that the values are increased with addition of fibers.

Table 1. Compressive strength of concrete

Compressive Strength (N/mm^2)		
Percentage of Fiber	7 Days	28 Days
0.0%	32.0	45.0
0.1%	28.0	37.0
0.2%	30.0	37.0
0.3%	31.0	36.0
0.4%	28.0	38.0
0.5%	27.0	33.0
0.6%	26.0	32.0
0.7%	25.0	31.0

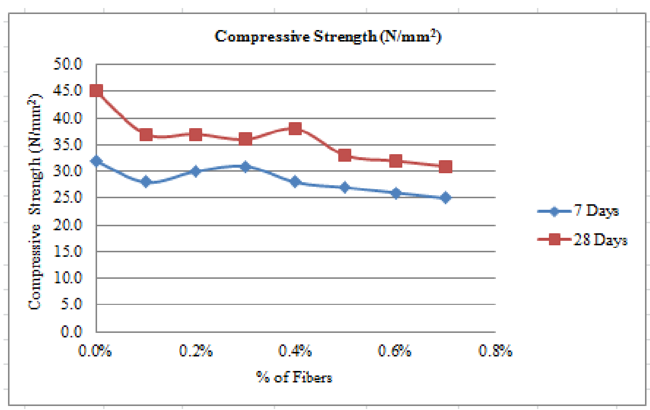

Fig.2: Compressive strength of cube specimens for different concrete mixes

Split Tensile Strength:

Split tensile test is done by placing the cylindrical specimen horizontally between the loading surfaces of a compression testing machine and the load is applied till the cylinder failed

along the vertical diameter. Split tensile strength of concrete mixes is determined at the age of 28 days. The mean tensile strength is calculated and tabulated in Table 2.
Split tensile strength = LOAD / AREA = 2P / LDπ

Table 2: Split Tensile Strength of Concrete

Split Tensile Strength (N/mm^2)		
Percentage of Fiber	7 Days	28 Days
0.0%	1.52	2.81
0.1%	1.79	2.88
0.2%	2.31	3.10
0.3%	2.36	2.97

From the Fig-3, it is observed that in case of 0.2% glass fiber, the split tensile strength attains a maximum value. The improvement in split tensile strength with respect to the controlled concrete is about 12%, 12% and 9% at mixes 0.1% glass fiber and 0.2% glass fiber, 0.3 % glass fiber respectively

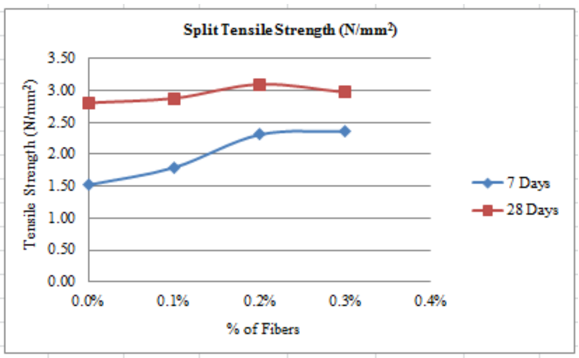

Fig-3 Split Tensile strength of cube specimens for different concrete mixes

Flexural Strength:

The flexural strength was studied and the values are shown in Table-3. It shows the data of 7 and 28 days obtained flexural strength. The flexural strength was also plotted in Fig.4. From the graph it is observed that the values are increased with addition of fibers

Table 3: Split Tensile Strength of Concrete

Flexural Strength (N/mm^2)		
Percentage of Fiber	7 Days	28 Days
0%	4.70	5.18
0.1%	4.76	6.49
0.2%	4.96	7.16
0.3%	5.62	7.81

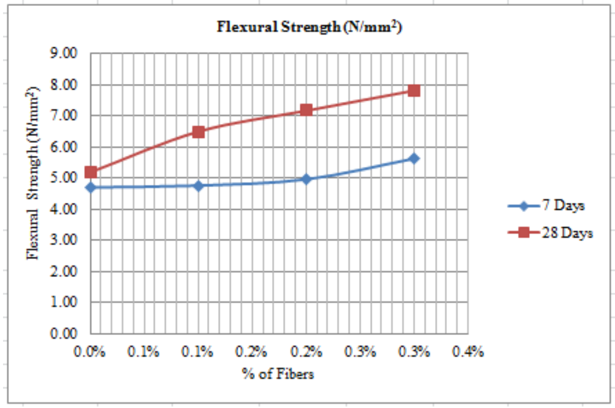

Fig-4 Flexural strength for different concrete mixes

Wet Transverse Strength:

The 28 days flexural tensile strength was studied and the average values of 3 samples studied are shown in the tabular form. Table 4 shows the data of 28 days wet transverse strength obtained. Table 4 gives the 28 days wet transverse strength of concrete with maximum nominal size of aggregates 8mm.The 28 days wet transverse strength was also plotted as shown in Fig.5 overall an increase in the wet transverse strength was observed with addition of fibers.

Table 4: Wet Transverse Strength of Concrete

Wet Transverse Strength (N/mm^2)	
Percentage of Fiber	28 Days
0.0%	1.41
0.1%	1.64
0.2%	1.72
0.3%	1.87
0.4%	1.94
0.5%	2.24
0.6%	2.39
0.7%	2.54

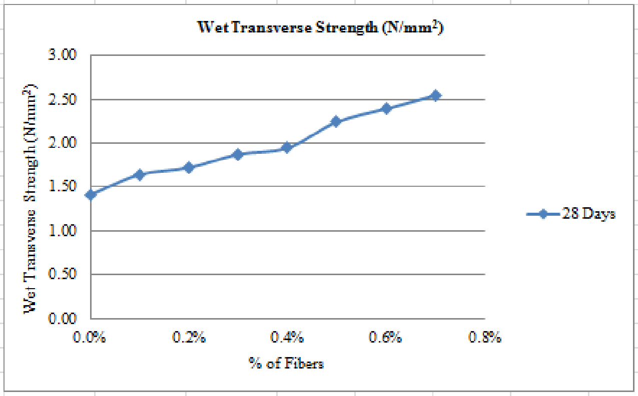

Fig-5 Wet Transverse strength of cube specimens for different concrete mixes

Water Absorption:

The water absorption of concrete after 28 days was studied and the average water absorption values of 6 samples obtained are shown in the tabular form. Table-5 shows the data of 28 days water absorption obtained. Table 5 gives the 28 days water absorption of concrete with maximum nominal size of aggregates 8mm.

Table-5: 28 days Water Absorption of Concrete

Water Absorption (%)	
Percentage of Fiber	28 Days
0.0%	2.69
0.1%	2.30
0.2%	1.95
0.3%	1.57
0.4%	1.22
0.5%	1.19
0.6%	1.17

Velocity Test:

Pulse velocity test was carried out on the tiles and the average values of the velocities which were not varying more than 15% are reported and the implications are shown in Table-6

Table-5: 28 days velocity Test of Concrete

Percentage of Fiber	Average Velocity (m/sec)	Grade of Concrete
0.0%	4497	Good
0.1%	4800	Excellent
0.2%	4365	Good
0.3%	4612	Excellent
0.4%	4395	Good
0.5%	4458	Good
0.6%	4386	Good
0.7%	4436	Good

V. CONCLUSION

In this experimental program the effect of short discrete glass fibers on the compressive, split tensile strength and flexural strength of concrete was studied.

The effect of glass fibers on cement and concrete tiles which are produced by vibration method are also studied. The properties studied are compressive strength, wet transverse strength and water absorption .The concrete mix gets harsher and less workable with increase of fiber content therefore use of admixture become necessary. However even after giving dosage of admixture as high as 1.5% proper workability could not be obtained and some segregation was observed. Therefore it was not possible to go beyond 0.7% fiber content.

The various observations based on the experimental result are as follows:

- The compressive strength of concrete without admixture is not affected by the presence of short discrete glass fibers with fiber content in the range 0.1 to 0.3 % of fiber content by weight of concrete.
- The split tensile strength of concrete increases with the addition of glass fibers
- The flexural strength of concrete increases with increase in fiber content and as such the tension carrying capacity of concrete may increase in flexure
- The wet transverse strength of tiles increases and the increase has been found with addition of fibers
- The water absorption of the concrete also decreases with increase in fiber content.
- The compressive strength of concrete with admixture was not affected up to 0.4 % fiber content but decreased with the presence of higher amount of fibers.

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