EFFECT OF CHOPPED GLASS FIBERS ON THE STRENGTH OF CONCRETE TILES

A THESIS SUBMITTED IN PARTIAL FULFILMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

B.TECH AND M.TECH (Dual)

in

Civil Engineering

Specialization Structural Engineering

BY

JAMBOO KUMAR JAIN

DEPARTMENT OF CIVIL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

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Under the guidance of

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CERTIFICATE

This is to certify that the thesis entitled, **"EFFECT OF CHOPPED GLASS FIBRES ON THE STRENGTH OF CONCRETE TILES" s**ubmitted by Mr. Jamboo Kumar Jain in partial fulfilment of the requirements for the award of Master of Technology Degree in Civil Engineering with specialization in Structural Engineering at the National Institute of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in this thesis has not been submitted to any other University/ Institute for the award of any degree or diploma.

Prof. S.K. SAHU

Civil Engineering Department

National Institute of Technology

Rourkela –769008

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- Jamboo Kumar Jain

Roll no: 710ce2012

Abstract:

The effect of glass fibre on flexural strength, split-tensile strength and compressive strength was studied for different fibre 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 .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 fibres used were 30mm and the glass fibres were alkali resistant. The effect of this short fibres 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 was also conducted.

Contents

CHAPTER 1

Introduction

1 INTRODUCTION

1.1 General

One of the most important building material 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 fibres 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 superplasticizers, admixtures, micro fillers are also being used to get the desired properties like workability, Increase or decrease in setting time and higher compressive strength.

Fibres which are applied for structural concretes are classified according to their material

As Steel fibres, Alkali resistant Glass fibres (AR), Synthetic fibres, Carbon, pitch and polyacrylonitrile (PAN) fibres.

1.2 Glass Fibre Reinforced Concrete

Glass fibre reinforced concrete (GFRC) is a cementitous composite product reinforced with discrete glass fibres of varying length and size. The glass fibre used is alkaline resistant as glass fibre 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 depends 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 fibre, sand/filler type, cement ratio methods and duration of curing also effect the properties of GFRC.

1.3 Applications

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.

1.4 Advantages And Disadvantages of using Glass Fibers in Concrete

1.4.1 Advantages

1. Lighter weight: With GFRC, concrete can be cast in thinner sections and is therefore as much as 75% lighter than similar pieces cast with traditional concrete. According to Jeff Girard's blog post titled, "The Benefits of Using a GFRC Mix for Countertops", a concrete countertop can be 1-inch thick with GFRC rather than 2 inches thick when using conventional steel reinforcement. A manufactured rock made with GFRC will measure a little portion of what a genuine rock of comparable extents would measure, taking into account lighter establishments and decreased delivering expense
2. High flexural strength, high strength to weight ratio.

3. Toughness: GFRC doesn't crack easily-it can be cut without chipping.

1.4.2 Disadvantages

1. Durability: According to ACI 544.1R-96, *State of the Art Report on Fiber Reinforced Concrete,* "The strength of fully-aged GFRC composites will decrease to about 40 percent of the initial strength prior to aging." Durability can be increased through the use of low alkaline cements and pozzolans.
2. GFRC as a material, however, is much more expensive than conventional concrete on a pound-for-pound basis.

1.5 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 fibre 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 is of practical use.

Chapter2

Literature Review

2 LITERATURE REVIEW

2.1 General

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 fibre reinforced concrete has developed. The term fibre-reinforced concrete (FRC) is defined by AC1 116R, Cement and Concrete Terminology, as concrete containing dispersed randomly oriented fibres. With time a lot of fibres 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 fibres has also evolved but its durability remains questionable. The work done by using different fibres, waste materials and their effects are discussed below in a sequential manner.

Use of fibres 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 fibre 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 fibre, size of fibre, orientation and distribution. American Concrete Institute (ACI) Committee 544 divided FRC broadly into four categories based on fibre material type. SFRC, steel fibre FRC; GFRC, glass fibre FRC; SNFRC, synthetic fibre FRC including carbon fibres; and NFRC, for natural fibre 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 fibres 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 fibre in concrete which lead the development of steel fibre 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 fibres applied for structural concretes and classified according to their material are Brandt:

– Steel fibres of different shapes and dimensions, also microfibers;

– Glass fibres, in cement matrices used only as alkali-resistant (AR) fibres;

– Synthetic fibres made with different materials: polypropylene, polyethylene and polyolefin, polyvinyl alcohol (PVA), etc.;

– Carbon, pitch and polyacrylonitrile (PAN) fibres.

Steel fibres are most important for structural concrete. Studies also reveal that hooks at the end of the steel fibres, 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 fibres 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 fibre 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, Ramakrishnan 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 this 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.

Fibre-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 fibres 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 wor

2.2 Waste Fibrous Materials:

Huge amount of waste materials are produced in our country. These waste materials are both organic and inorganic. The amount of inorganic waste material produced is increasing day by day and to dispose them of without causing any harm to environment is a big problem. Many researches are now trying to use the waste material as construction materials. Also natural fibres are available in abundant and can be an alternate for use in construction of cost effective materials in urban and rural buildings.

2.3 Inorganic Fibers**:**

Kenneth W. Stier and Gary D. Weede (1999) investigated the feasibility of recycling commingled plastics Fibre in Concrete.It was found that the mechanical properties of concrete such as compressive and flexural strength showed improvement but however the durability aspect was questionable. Sekar (2004) studied on fibre reinforced concrete from industrial lathe waste and wire winding waste and found that this waste significantly improved the compressive, split-tensile strength and the flexural strength values of concrete. It also stated that wire drawing industry waste decreased the strength values. Effect of re-engineered plastic shred fibre were studied by Anbuvelan et al (2007). The engineering properties Compressive, split tensile, flexural, abrasion, impact strength and plastic shrinkage of the concrete was found to have improved.

2.4 Natural Fibres:

Natural fibres were traditionally used in the past as reinforcing materials and their use so far has been traditional far more than technical. They have served useful purposes but the application of natural fibre as a reinforcing material for concrete is a new concept. Improved tensile and bending strength, , greater resistance to cracking and hence improved impact strength and toughness ,greater ductility are some of the properties of natural fibre reinforced concrete. Ramakrishna et al (2002) looked at the hypothetical and exploratory examinations on the compressive quality and elastic modulus of coir and sisal fibre strengthened cements for different volume divisions. It was watched that both the exploratory and analytical values of flexible modulus had indicated 15% error, which can be viewed as relatively little. Rheological properties of coir fiber strengthened cement mortar were done by Ramakrishna and Sundararajan (2002).Flow value, cohesion and angle of internal friction were resolved for three different mix ratios and four different aspect ratios and fibre contents. In view of the rheological properties of fresh mortar, it was prescribed to use short filaments with low fibre-content for achieving workability and higher fibre content for better cohesiveness in wet state. Composites of blast furnace slag BFS based cement mortar strengthened with vegetable strands were presented by Holmer Savastano Jr et al(1998). Composites were produced through a straightforward and low-vitality expending strategy, including standard vibration and curing in a wet chamber. Eucalyptus pulp, coir fibres and with a mixture of sisal fibre and eucalyptus pulp gave a suitable performance but the performance deteriorated with time. The natural fibre composites may undergo a decrease in strength and toughness as a result of debilitating of fibres by the combination of alkali attack and mineralisation through the migration of hydrogen products to lumens and spaces. Romildo D. Toledo Filho et al (2003) reported their study on development of vegetable fibre-mortar composites of improved durability. So a few methodologies were proposed by the authors to enhance the solidness of vegetable fiber-concrete composites. These incorporate carbonation of the grid in a CO_2-rich environment; the drenching of strands in slurried silica fume earlier to joining in Ordinary Portland Cement lattice; incomplete substitution of Ordinary Portland Cement by undensified silica fume or blast furnace slag. The execution of adjusted vegetable fiber-mortar composites was investigated in terms of impacts of maturing in water, presentation to cycles of wetting and drying and open air weathering on the microstructures and flexural conduct. It was recommended that submersion of common strands in a silica seethe slurry before the expansion to the bond based composites was discovered to be an successful method for decreasing embrittlement of the composite in nature. Additionally early cure composites in a CO_2- rich environment and the fractional substitution of OPC by undensified silica smoke were the proficient methodologies in getting regular strands with enhanced sturdiness.

2.5 Modelling Approach

Mechanical characterization and impact behaviour of concrete reinforced with natural fibres were studied by Al-Oraimi and Seibi (1995). Here, an exploratory study was led utilizing palm tree and glass filaments on high quality cement. Mechanical quality properties, for example, compressive strength, part ductile, flexural qualities and post breaking toughness were concentrated on. It was reasoned that common strands will be similar with glass filaments. A limited component examination was additionally done utilizing ANSYS programming. Both the expository and test results were analysed and adequate. Antonia F. Barbosa and Gabriel O. Ribeiro (1998) worked on ANSYS for limited component investigation of reinforced solid structures. An essentially upheld fortified concrete bar subjected to consistently conveyed burden was taken as a basic sample in that study Two different models were considered for steel reinforcement such as discrete and smeared. Load –deflection curves obtained through ANSYS have been compared with experimental results and they have been found to be satisfactory.

Finite element analysis using ANSYS was done by Greeshma and Jaya (2007) to analyse a shear wall under seismic loading. Modelling of shear 21 wall was done using SOLID 65 model and reinforcements were modeled using LINK 8 element. The analyses were carried out for the shear wall, subjected to both static and dynamic loading.

2.6 Analytical Approach

One of the important applications of fibre reinforced concrete involves making earthquake resistant structures. Not only earthquakes, most of the unanticipated loadings are cyclic in nature. The behaviour of fibre 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 modelling 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 fibres 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 fibre reinforced concrete is also good.

Chapter 3

Materials and Methods

3 MATERIALS AND METHODS

3.1 Materials

3.1.1 Concrete

Concrete is the most widely used construction material. The basic materials of concrete are Portland cement, water, fine aggregates i.e. sand and coarse aggregates. The cement and water form a paste that hardens and bonds the aggregates together. Concrete in fresh state is plastic and can be easily moulded to any shape, as time passes it hardens and gains strength. The initial gain in strength is due to a chemical reaction between water and C2s and latter gain in strength is due to reaction between C3s and water. Concrete is produced by either following nominal mix proportions in which the mix proportions are fixed as per grade of concrete required or mix design proportions, latter produces more economical concrete.

In our work Portland slag cement (PSC) -43 grade Konark cement was used. Standard consistency, initial setting time, final setting time, 28-day compressive strength tests were carried out as per the Indian standard specifications. Clean river sand passing through 4.75 mm sieve was used as fine aggregates. The specific gravity of sand was 2.68 and grading zone of sand was zone 3 as per IS .Angular stones were used as coarse aggregates maximum size 20mm and specific gravity 2.72.Concrete was mixed and cured by ordinary water or tap water.

For casting cubes, cylinders and prisms maximum size of aggregate used was 20mm whereas in case of tiles the maximum size of aggregates used was 8mm.The water cement ratio used for concrete tiles was 0.45 and admixture was used to attain the desire workability.

3.1.2 Cement

Cement is an extremely ground material having adhesive and cohesive properties which provide a binding medium for the discrete ingredients. The processes used for manufacture of cement can be classified as dry and wet.. The cement commonly used is Portland cement, it is also defined as hydraulic cement, i.e. a cement which hardens when it comes with water due to chemical reaction but there by forming a water resistant product. Portland cement is obtained when argillaceous and calcareous materials are grounded to fine powder and mixed in definite proportion and fused at high temperature. When blast furnace slag is also used as one of the ingredients than the cement obtained is called Portland slag cement (PSC). Portland slag cement (PSC) – 43 grade (Konark Cement) was used for the experimental programme.

3.1.3 Fine Aggregates

Aggregates are generally obtained from natural deposits of sand and gravel, or from quarries by cutting rocks. The least expensive among them are the regular sand and rock which have been lessened to present size by characteristic specialists, for example, water, wind and snow and so on. The stream stores are the most well-known and are of good quality. The second most regularly used source of aggregates is the quarried rock which is reduced to size by crushing. The size of aggregates used in concrete range from few centimetres or more, down to a couple of microns. Fine aggregates is the aggregate most of which passes through a 4.75mm IS sieve and contains just that much coarser material as allowed by the IS details. The fine aggregate used for the experimental programme was obtained from river bed of Koel. The fine aggregate passed through 4.75 mm sieve and had a specific gravity of 2.68. The sand belonged to zone III as per IS standards.

3.1.4 Coarse Aggregates

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.

3.1.5 Water

Water is the one most essential element of cement. Water assumes the vital part of hydration of concrete which frames the coupling lattice in which the dormant totals are held in suspension medium until the grid has solidified, furthermore it serves as the lubricant between the fine and coarse aggregates and makes concrete workable.

3.1.6 Fiber

Fibre is a natural or synthetic string or used as a component of composite materials, or, when matted into sheets, used to make products such as paper, papyrus, or felt. Concrete is brittle by nature and is weak in flexure as well as direct tension therefore in order to improve this properties fibres are added to concrete. Fibres may be short discrete or in forms of rods or may be even in form of textile fibres or woven mesh fibres. Various types of fibres have been added to concrete some have high modulus of elasticity some have low modulus of elasticity each category can improve certain properties of concrete. In our case short discrete glass fibres were used and as glass fibre is susceptible to alkali we used alkali resistant glass fibres. A fiber is a material made into a long filament with a diameter generally in the order of 10 tm. The main functions of the fibers are to carry the load and provide stiffness, strength, thermal stability, and other structural properties in the FRC.

Glass strands are filaments generally utilized as a part of the maritime and mechanical fields to create composites of medium-elite. Their unconventional trademark is their high quality. Glass is basically made of silicon (SiO2) with a tetrahedral structure (SiO4). Some aluminum oxides and other metallic particles are then included different extents to either facilitate the working operations or change a few properties (e.g., S-glass strands show a higher elasticity than E-glass).

The era development of fiberglass is fundamentally in light of turning a bunch made of sand, alumina, and limestone. The constituents are dry mixed and passed on to melting (around 1260°C) in a tank. The liquefied glass is conveyed straightforwardly on platinum bushings and, by gravity, goes through specially appointed openings situated on the base. The fibers are then gathered to shape a strand ordinarily made of 204 fibers. The single fiber has a normal measurement of 10 µm and is regularly secured with a measuring. The yarns are then packaged, much of the time without curving, in a meandering. Glass filaments are likewise accessible as slim sheets, called mats. A mat may be made of both long persistent and short strands (e.g., irregular filaments with an ordinary length somewhere around 25 and 50 mm), haphazardly organized and kept together by a concoction bond. The width of such tangles is variable between 5 cm and 2 m, their thickness being around 0.5 kg/m^2. Glass filaments normally have a Young modulus of versatility lower than carbon or aramid strands and their scraped area resistance is moderately poor; consequently, alert in their control is needed. Likewise, they are inclined to crawl and have low exhaustion quality. To upgrade the bond in the middle of filaments and grid, and to secure the strands itself against soluble operators and dampness, strands experience estimating medicines going about as coupling specialists. Such medicines are helpful to improve toughness and weakness execution (static and element) of the composite material. FRP composites taking into account fiberglass are normally meant as GFRP.

3.1.7 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 fibre content the mixture was becoming stiffer.

The experimental work consists of casting cubes, cylinders and prisms to study the effect of glass fibres on the compressive, flexural and split tensile strength of concrete. The effect was studied by varying the fibre content from 0% to 0.3%, no water reducing admixture was used for the experimental programme. To check the effect on concrete for fibre content variation 6 specimens each of cube, prisms and cylinders were casted. Test were conducted on the specimen after 7days and 28 days.

Further in order to get a practical use of glass fibres in concrete, concrete tiles were casted.The size of the tiles being 400mm*400mm*20mm.The maximum size of aggregates used for 8mm in case of tiles and the testing for tiles were done as per IS 1237:2012.The fibre content varied from 0% to 0.7% and the main study of interest was compressive strength, wet transverse strength and water absorption.

3.2 Casting Of Tiles

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 figure 1.

Figure 1 Mold for casting of tiles

3.3 Materials For Casting

3.3.1 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.

3.3.2 Fine Aggregates

The fine aggregates used for experimental programme was obtained from bed of river Koel.The fine aggregates used passed through 4.75mm sieve and had a specific gravity of 2.68.The fine aggregates belonged to Zone III according to IS 383 .

3.3.3 Coarse Aggregates

The coarse aggregates used were non-reactive and as per the requirements to produce a good and durable concrete .The coarse aggregates were of two different grading and as such a definite mix proportion was used to obtain the desire grading for coarse aggregates. One grade has maximum size of 10mm and minimum 4.75mm and for the other the maximum size was 20mm and minimum 10mm.This combination was used for casting cubes, cylinders and prisms. For casting cement and concrete tiles a maximum size of 8mm and retained on 4.75mm was used. The coarse aggregates for casting tiles was obtained by sieving 10mm down aggregates.

3.3.4 Water

Ordinary tap water which is safe and potable for drinking and washing was used for producing all types of mix.

3.3.5 Glass Fibers

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

1. A-glass: Also known as alkali glass and is made from soda lime silicate.
2. AR-glass: Alkali resistant glass and is made from zirconium silicates.this type of glass fibers are used in cement substrates.
3. C-glass: This type of glass fibers are used in acid corrosive environments Made from calcium borosilicate’s
4. D-glass: Low dielectric constant made with borosilicate’s.
5. E-glass: This glass fibers have very high electrical resistance and are very commonly used.
6. ECR- glass: An E-glass which has higher acid corrosion resistance
7. R-glass: It is a support glass and is utilized where higher quality and corrosive erosion resistance is needed.
8. S-glass: Also known as structural glass and are in use where high quality, high firmness, compelling temperature resistance and destructive resistance is required.

   In our case AR-glass fibers were used. The glass fibers used had a density of 2.7 gm/cm^3, tensile strength 1700 MPa and Young’s Modulus 72GPa.

3.3.6 Form Work

Form work may be defined as a temporary structure or a permanent structure used to contain poured concrete in fresh state. Fresh concrete is plastic and can be easily moulded formwork plays an important role in shaping the concrete and also support it until it gains sufficient strength to support itself. It is required that the formwork be sufficiently strong to take the dead load and live load that may come upon it during construction and also it should be sufficiently rigid at the same time to avoid bulging, twisting , swaging due to these loads. Dead loads refer to the load or weight of the forms and the weight of the fresh concrete. The live loads may be taken as the weight of the workers, equipments, runways and material storage and compacting equipments.

In our case permanent moulds were used which are commercially available in market. However for preparation of tiles moulds were specially ordered and procured from local steel fabricating shops.

3.4 Mixing Of Concrete

In order to obtain a uniform mix thorough mixing of concrete is necessary. Concrete can be produced in two ways either by hand mixing or machine mixing. Hand mixing can be done on a plane levelled surface such as a wooden platform or a paved surface having tight joints so as to prevent paste loss To do mixing first the surface is cleaned and then moistened after that sand is first poured on the surface and then cement is spread on the sand after that thorough mixing is done. When the cement and sand gets uniformly mixed coarse aggregates are spread over the uniform sand and cement mix and then again mixed thoroughly. To mix the materials either a hoe or a square-pointed D-handled shovel is used. Dry materials are mixed until the colour of the mixture is uniform. Having obtained uniform coloured dry mix water is slowly added and the mix is again turned at least three times after completely the entire mixing process fresh concrete is produced which is plastic and can be moulded as per our needs.

In our investigation machine mixing was done to produce the fresh concrete. First the machine drum was cleaned and then moistened so as to prevent any loss of water as we are adding only a calculated amount and no extra water is added. All the dry materials are put in the drum and then dry mixed by rotating the drum when a thorough mix is obtained glass fibres are added as per the calculated which is a percent of total weight of concrete and then the materials are mixed thoroughly. After that water is added and mixed again until a uniform coloured mix is obtained. After completing all this process the concrete is dropped on a flat and clean plate from where we take it and fill our moulds.

3.5 Compaction

All specimens were first filled in their respective moulds and then hand compacted using a rod of 30mm diameter in three layers by tamping 20 times on each layer .To attain full compaction the specimens were than vibrated on a vibrator table. The tiles were prepared by putting the concrete in the mould and then hand tamping using a plane surfaced wooden block and then the mould was held tight by hands and vibrated on the vibrator table .The surface was levelled, finished and smoothened by metal trowels.

3.6 Curing Of Concrete

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.

CHAPTER 4

Experimental Setup

4 EXPERIMENTAL SETUP

Various tests conducted on the specimens are described below along with the description and importance.

There were two ways in which the investigation was carried out one in which only cubes, cylinders and prisms were casted and the grade of concrete was M-20.The proportioning of the concrete was .The nominal maximum size of aggregate was 20mm and no admixture was used.

4.1 Compressive strength

The most important property of concrete is its compressive strength and durability. Concrete is mostly used in construction where load transferred is mostly via compressive strength. In order to check the effect of fibres on the compressive strength of concrete 150mm cubes were cast and tested .The cubes were tested at the age of 7days and 28 days and the variation was noted.

Fibre content was varied from 0% to 0.3% when the nominal maximum size of aggregates was 20mm and no admixture was used. The water cement ratio was fixed at 0.5.The workability of the mix was observed to come down but however no extra water was used.

4.2 Split Tensile Strength

Concrete may be subjected to tension in very rare cases and is never designed to resist direct tension. However, the load at which cracking would occur is important and needs to be determined. The tensile strength of concrete as compared to its compressive strength is very low and is found to be only 10-15 % of the compressive strength. There are various factors which influence the tensile strength of concrete like aggregates, age, curing, air-entrainment and method of test.

To conduct the split tension test a cylindrical concrete specimen is loaded along its length as a result of the loading tensile stresses are developed along the central diameter along the lateral direction. The specimen splits into two when the limiting tensile strength is reached and this value can be calculated from the load given below

A diagram is shown to show how the test is carried out:

4.3 Flexural Strength

Flexural strength is also a measure of the tensile strength of concrete. In practical concrete may not be subjected to direct tension but it is subjected to flexure in many cases particularly in beams which is a flexural member. Flexural strength is also referred to as modulus of rupture. In order to calculate the flexural strength a

4.4 Tests carried out on Cement and Concrete Tiles

Cement and concrete flooring tiles are tested as per IS 1237:2012 There are various tests given in the code but we have done the water absorption test and wet transverse strength .Other tests that were conducted on the tiles was the pulse velocity test which is a non-destructive test and predicts the quality but not the grade of concrete. The IS code does not say anything about the compressive strength test but however in order to check the compressive strength six 100mm cubes were cast and tested at 7 days and 28 days.

4.5 Water absorption test

Six tiles were immersed in water for 24hrs, than the tiles were taken out and wiped dry. Each tile was immediately weighted after saturation. The tiles were then placed in an oven at 65^0C for 24 hrs and then cooled and reweighed at room temperature.

Water absorption was calculated using the formula as given below:

$$\frac{M1 - M2}{M2} X100$$

Where

M1= mass of the saturated specimen;

M2= mass of the oven-dried specimen.

4.6 Wet Transverse Strength Test

In order to determine the wet transverse strength of tiles six full sized tiles are tested at 28 days as per the guidelines given by IS 1237:2012 .Before performing the test the tiles are soaked in water for 24 hrs and then placed horizontally on two parallel steel supports, the wearing surface is upwards and its sides parallel to supports. The load is applied in such a way that the steel rod is parallel to supports and midway between them.It is required that the length of the supports and of the loading rod shall be longer than the tile. The diameter of the loading rod shall be 12mm and be rounded. The load is applied at a uniform rate of 2000N/min, until the tile breaks. The wet transverse strength is calculated using the formula given in IS code as given below:

$$\frac{3PI}{2bt^2} N/mm^2$$

Where,

P = breaking load in N;

I = span between supports, in mm;

b = tile width, in mm; and

t = tile thickness, in mm.

4.7 Compressive Strength

To get the compressive strength variation due to glass fibres 100mm cubes were cast with the same mix as used for casting concrete tiles with the same amount of admixtures. Six 100mm cubes were cast for each fibre content. Three cubes were tested at 7days and three at 28 days. The compressive test was done on universal testing machine. The cubes were cured using pond curing method and before testing they were allowed to surface dry. The formula used for calculating compressive strength is given below:

$$c = \frac{P}{A} N/mm^2$$

Where,

P=load in Newton (N) at which failure occurs,

A=surface area in $mm^{2.}$

4.8 Pulse Velocity Test

The pulse velocity test is a non-destructive test and is covered in IS 13311 (Part 1) – 1992.It gives a measure of the quality of concrete. The underlying principle of this test is –

The method consists of measuring the time of travel of an ultrasonic pulse passing through the concrete being tested. Comparatively higher velocity is obtained when concrete quality is good in terms of density, uniformity, homogeneity etc. First couplant is applied to the surfaces of the transducers and pressed hard onto the surface of the material. The transducers are not moved while a reading is being taken, as this can generate noise signals and errors in measurements. The transducers are continuously held onto the surface of the material until a consistent reading appears on the display, which is the time in microsecond for the ultrasonic pulse to travel the distance ‘L’. The mean value of the display readings is taken when the unit’s digit hunts between two values. The velocities obtained can be interpreted in the form of quality of concrete and not in form of the grade of concrete.

Pulse velocity= (Path length/Travel time)

4.9 Procedure

Experiments started with the preliminary tests on material properties as per the Indian standards. Composites being made of cement, fiber and sand as major components tests were conducted for standardizing properties of these materials. Tests of physical properties of sand, cement and fiber were conducted first and then they were used in the research. NO tests were conducted on water as ordinary tap water from govt. water supply was used throughout the research work.

Specific gravity test: The test was conducted as per IS 2720-part iii to obtain the specific gravity of cement. The specific gravity of cement was found to be 3.10.

Consistency Test: As per IS 4031-part iv 1988 a consistency test was done on the cement using Vicat's apparatus confirming to IS 5513 .The standard consistency was found to be 30%.

Fineness test : Fineness of the cement was tested as per IS 4031-part 1 by the method of sieve analysis. A 10g sample of cement was agitated for 2 mins over a 90 micron sieve . The test results proved that almost all the cement passed through the sieve and negligible weight of dust was retained.

Test for the grade of cement (Compressive strength test): AS per the guidelines of IS 4031-part vi 1988 cubes of cement mortar were casted at water content of(P/4 + 3 %) of total dry mass taken and were tested for 7 day and 28 day strength. For simplicity ,3 day strength test was omitted .until tests the casted cubes were kept in water for curing.The minimum 7 day compressive strength averaged over three cubes was 24.33 MPa and 28 day strength averaged over three cubes was 41.67MPa.

4.10 Test on sand

Specific gravity test: The specific gravity of sand was measured using a pycnometer by the procedure confirming to IS 2386 part iii-1963.The specific gravity was found to be 2.66

Sieve analysis of sand : In order to ascertain the particle sine distribution of sand Dry sieve analysis was carried out. The sieve sizes were as per IS 2386-part I. The zone of sand was zone iii.

4.11 Preparation of M-20 grade concrete

M-20 grade concrete was prepared using the mix design guidelines as per IS -10262 without using admixture. A water cement ratio of 0.50 was adopted as fibre reduces the workability of concrete to a great extent. Maximum .3% chopped fibres by weight of concrete were added to check the effect of fibres on the properties of concrete as even at 0.3 % the concrete turned very harsh and a great deal of vibration was needed. Total 4 different batches of M-20 grade concrete was prepared with 0, 0.1, 0.2 and 0.3 percent fibre.

CHAPTER5

Results

5 RESULTS

The results obtained are shown below in tabular form

5.1 Compressive Strength of Concrete (in N/mm^2)

The 7 days compressive strength was studied and the values of 3 samples studied are shown in the tabular form.Table 1 shows the data of 7 days compressive strength obtained. Table 1 gives the 7 day compressive strength of concrete with maximum nominal size of aggregates 20mm.The 7 days compressive strength was also plotted Fig2 by taking the average of this three values overall an increase in the compressive strength was observed with addition of fibers.

Table 1 7days compressive strength of concrete

Serial number	Without fibre	0.1% fibre	0.2%	0.3%
1	16.89	17.77	21.33	22.22
2	16.44	17.33	20.88	22.67
3	16.44	17.33	21.33	23.11

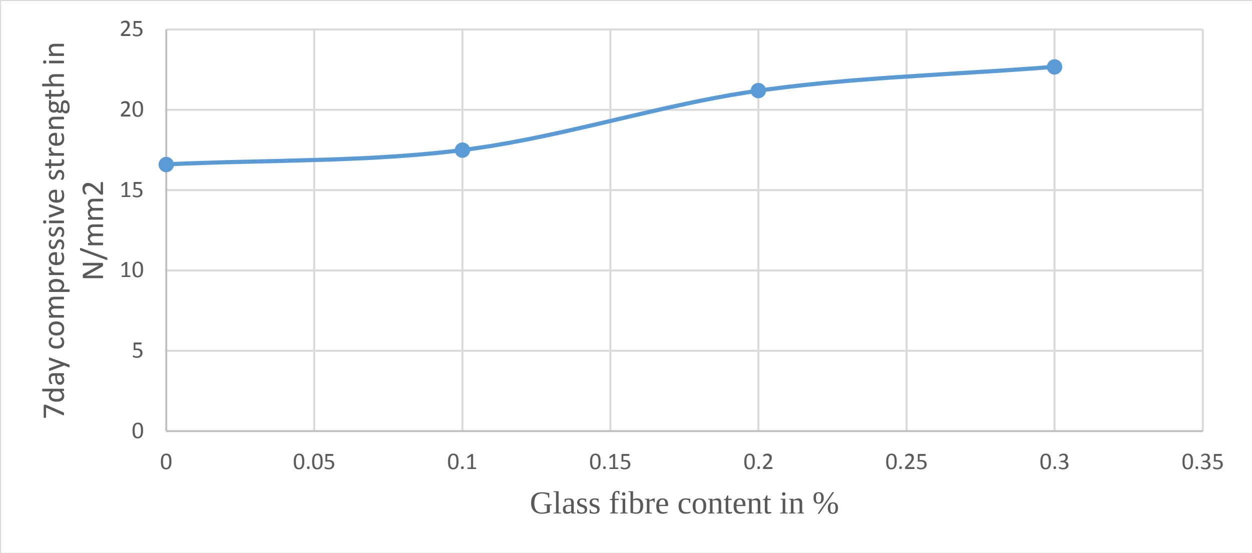

Figure 2: Effect of Glass fibers on 7 day compressive strength

The 28 days compressive strength was studied and the values of 3 samples studied are shown in the tabular form. Table 2 shows the data of 28 days compressive strength obtained. Table 2 gives the 28 days compressive strength of concrete with maximum nominal size of aggregates 20mm.The 28 days compressive strength was also plotted Fig3 by taking the average of this three values overall an increase in the compressive strength was observed with addition of fibers.

Table 2 28 days compressive strength of concrete

Serial number	Without fibre	0.1%	0.2%	0.3%
1	25.33	28	28.88	30.22
2	25.77	31	28.88	28.88
3	25.33	28	31	30.66

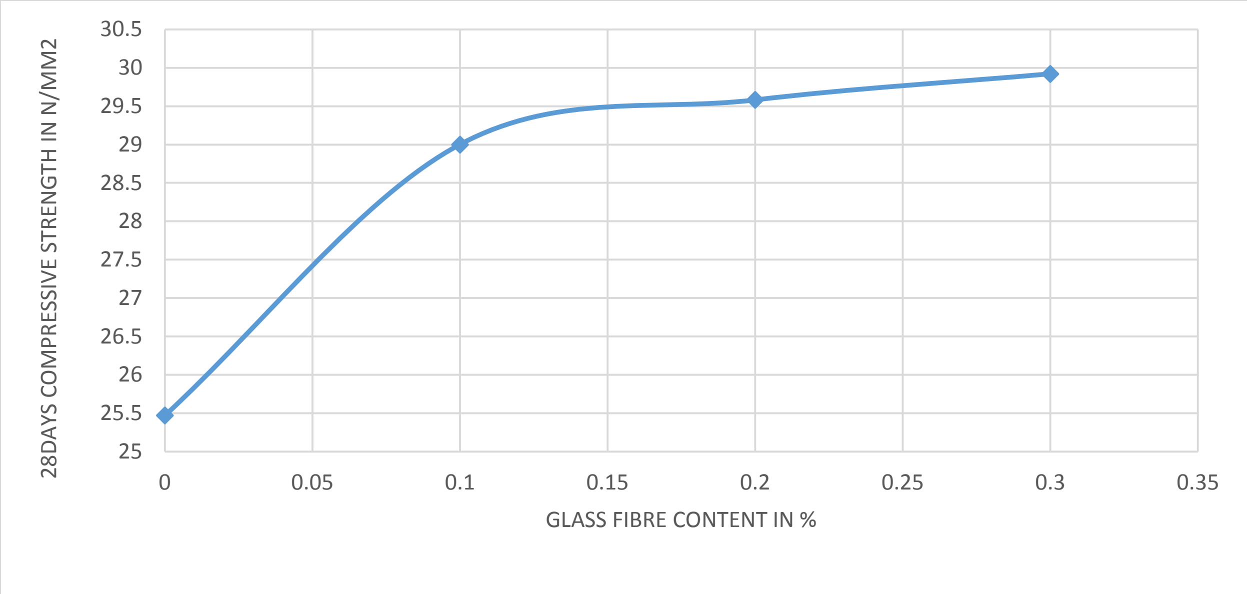

Figure 3 Effect of Glass fibers on 28 day compressive strength

5.2 Split Tensile Strength comparison (in N/mm^2)

The 7 days Split Tensile strength was studied and the values of 3 samples studied are shown in the tabular form.Table 3 shows the data of 7 days compressive strength obtained. Table 3 gives the 7 days compressive strength of concrete with maximum nominal size of aggregates 20mm.The 7 days compressive strength was also plotted Fig4 by taking the average of this three values overall an increase in the compressive strength was observed with addition of fibers.

Table 3 7days Split Tensile Strength of Concrete

Serial number	Without fibre	0.1%	0.2%	0.3%
1	1.485	1.84	2.405	2.405
2	1.626	1.70	2.26	2.405
3	1.45	1.84	2.26	2.263

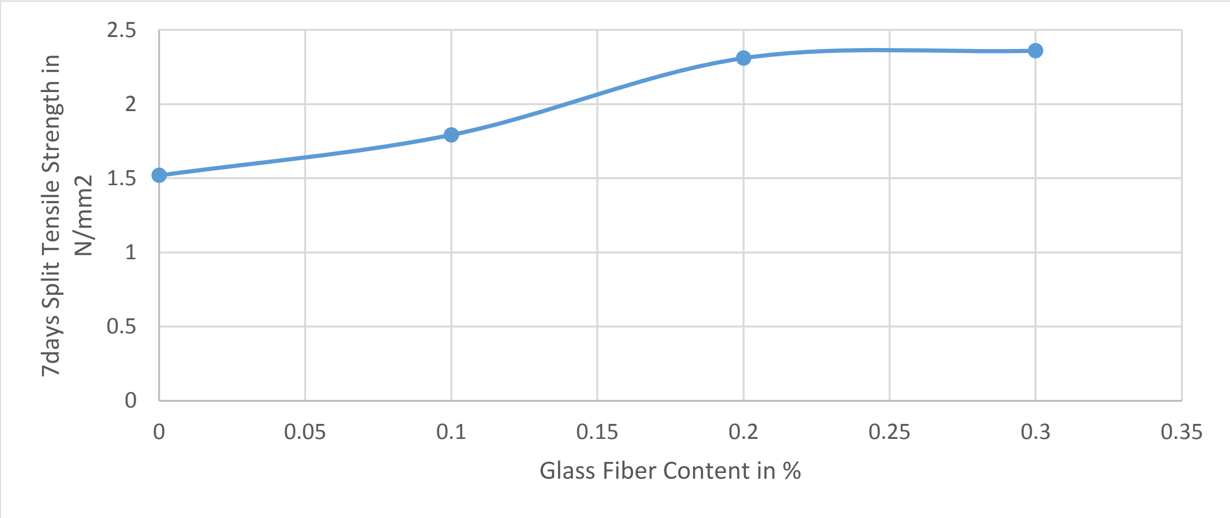

Figure 4 Effect of Glass fibers on 7days split tensile strength

The 28 days Split Tensile strength was studied and the values of 3 samples studied are shown in the tabular form. Table 4 shows the data of 28 days compressive strength obtained. Table 4 gives the 28 days compressive strength of concrete with maximum nominal size of aggregates 20mm.The 28 days Split Tensile strength was also plotted Fig5 by taking the average of this three values overall an increase in the compressive strength was observed with addition of fibers.

Table 4 28 days Split Tensile Strength of Concrete

Serial number	Without fibre	0.1%	0.2%	0.3%
1	2.829	2.83	2.97	2.97
2	2.76	2.83	2.97	2.97
3	2.829	2.97	3.35	2.97

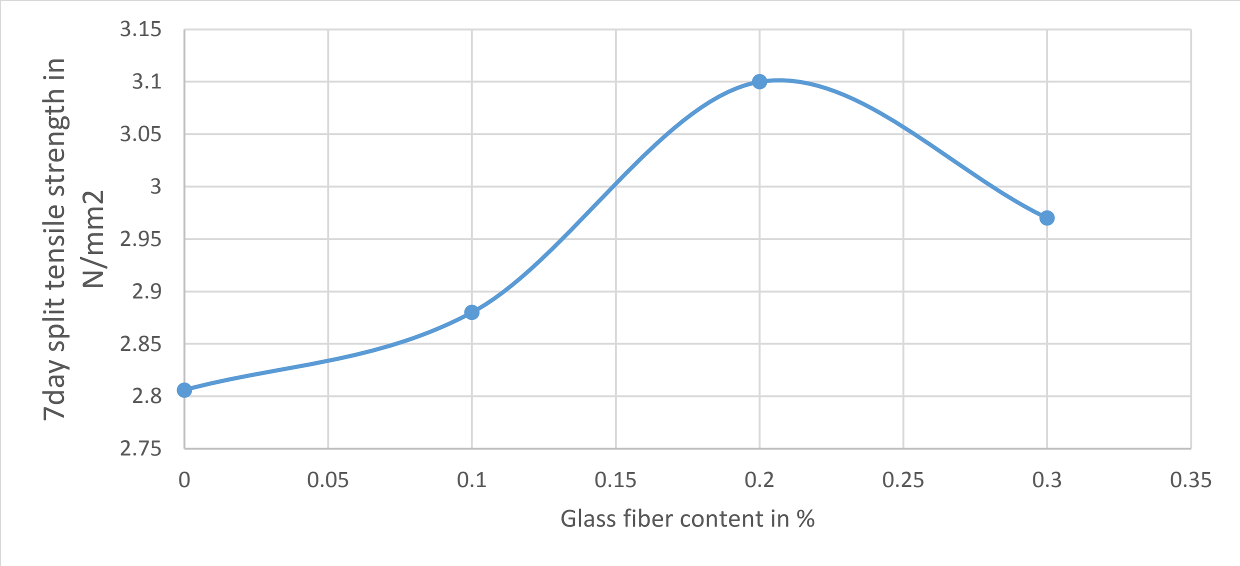

Figure 5 Effect of Glass fibers on 28days Split Tensile Strength

5.3 Flexural Tensile Strength (in N/mm^2)

The 7 days Flexural Tensile strength was studied and the values of 3 samples studied are shown in the tabular form.Table 5 shows the data of 7 days flexural tensile obtained. Table 5 gives the 7 day compressive strength of concrete with maximum nominal size of aggregates 20mm.The 7 days compressive strength was also plotted Fig6 by taking the average of this three values overall an increase in the compressive strength was observed with addition of fibers.

Table 5 7 days Flexural Strength of Concrete

Serial number	Without fibre	0.1%	0.2%	0.3%
1	4.6	4.744	4.988	5.744
2	4.7	4.776	4.988	5.424
3	4.8	4.756	4.9	5.704

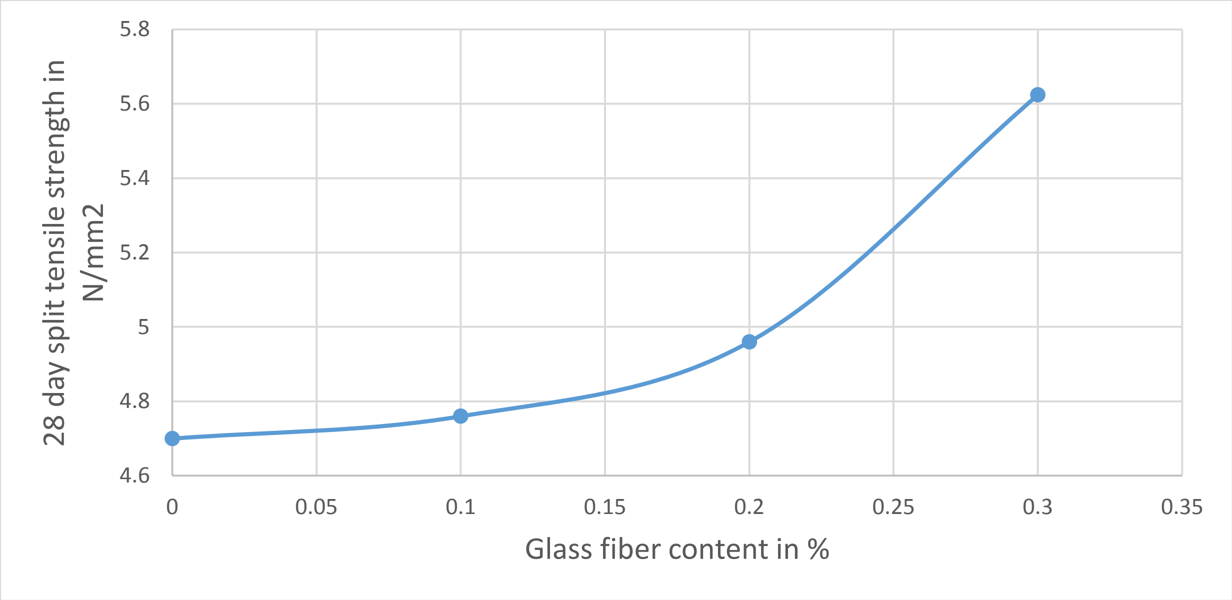

Figure 6 Effect of Glass fibers on 7 days Flexural strength

The 28 days flexural tensile strength was studied and the values of 3 samples studied are shown in the tabular form.Table 6 shows the data of 28 days compressive strength obtained. Table 6 gives the 28 days flexural tensile strength of concrete with maximum nominal size of aggregates 20mm.The 28 days flexural tensile strength was also plotted Fig7 by taking the average of this three values overall an increase in the compressive strength was observed with addition of fibers.

Table 6 28 days Flexural Strength of Concrete

Serial number	Without fibre	0.1%	0.2%	0.3%
1	5.104	6.368	7.544	7.156
2	5.204	6.456	7.104	7.96
3	5.242	6.652	6.844	8.32

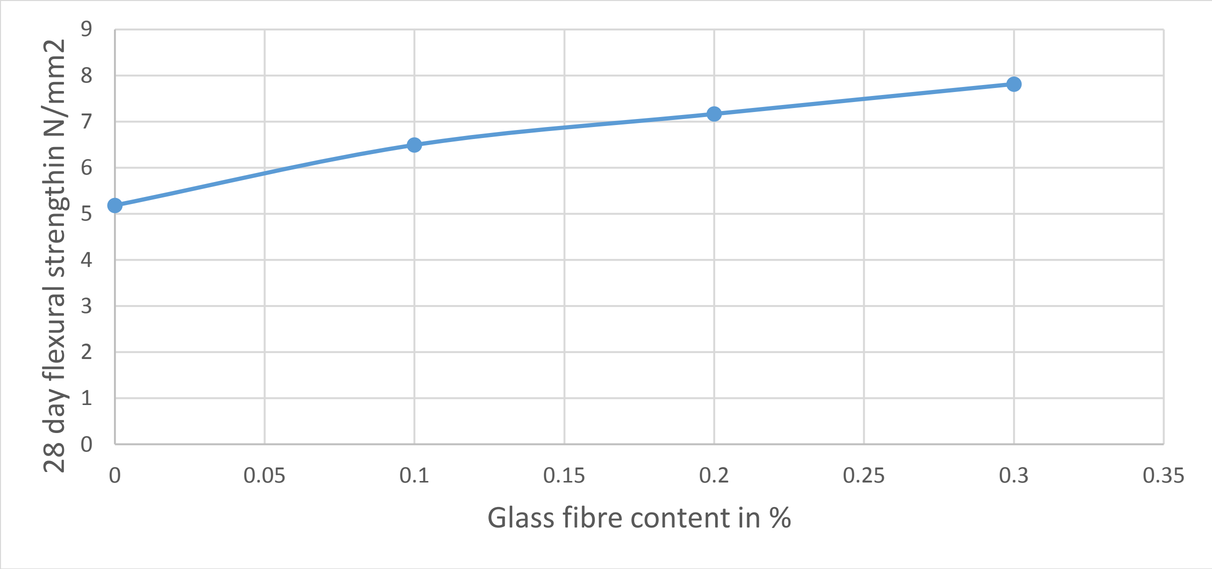

Figure 7 Effect of Glass fibers on 28 days Flexural strength

5.4 Tests carried out on cement and concrete tiles

Cement and concrete tiles were tested as per IS 1237:2012.The test performed were wet transverse strength, water absorption test .Compressive strength test is not mentioned in the code but it was performed as fibers can reduce the strength of the concrete. Pulse velocity test and natural frequency test were also conducted. The results obtained are given below in tabular form:

5.4.1 Compressive strength test

The 7 days compressive strength was studied and the average values of 3 samples studied are shown in the tabular form. Table 7 shows the data of 28 days compressive strength obtained. Table 7 gives the 7 days compressive strength of concrete with maximum nominal size of aggregates 8mm.The 7 days compressive strength was also plotted as shown in Fig8 overall a decrease in the compressive strength was observed with addition of fibers.

Table 7 7days Compressive Strength of Concrete

Fibre content(% of the total weight of concrete)	WEIGHT(KG)	Average 7 days compressive strength (N/mm^2)
0	2.495	32
0.1	2.478	28
0.2	2.478	30
0.3	2.500	31
0.4	2.487	28
0.5	2.500	27
0.6	2.400	26
0.7	2.390	25

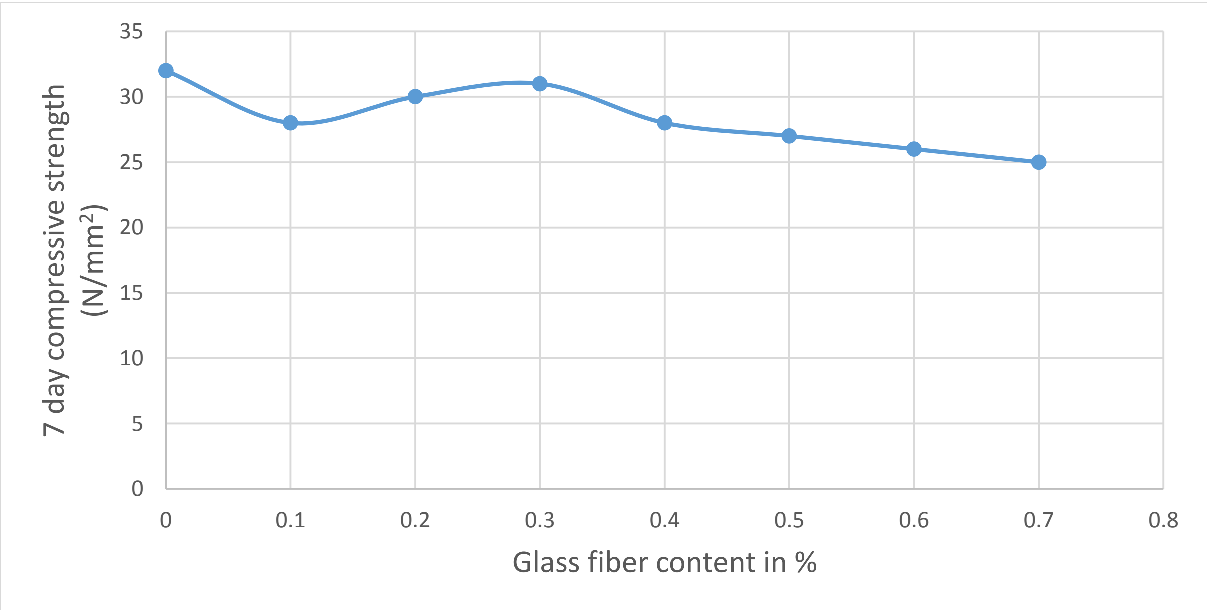

Figure 8 Effect of Glass fibers on 7 days Compressive strength

The 28 days Compressive strength was studied and the average values of 3 samples studied are shown in the tabular form. Table 8 shows the data of 28 days compressive strength obtained. Table 8 gives the 28 days compressive strength of concrete with maximum nominal size of aggregates 8mm.The 28 days compressive strength was also plotted as shown Fig9 overall a decrease in the compressive strength was observed with addition of fibers.

Table 8 28days Compressive Strength of Concrete

Fibre content(% of the total weight of concrete)	WEIGHT(KG)	Average 28 days compressive strength (N/mm^2)
0	2.495	45
0.1	2.478	37
0.2	2.478	37
0.3	2.500	36
0.4	2.487	38
0.5	2.500	33
0.6	2.400	32
0.7	2.390	31

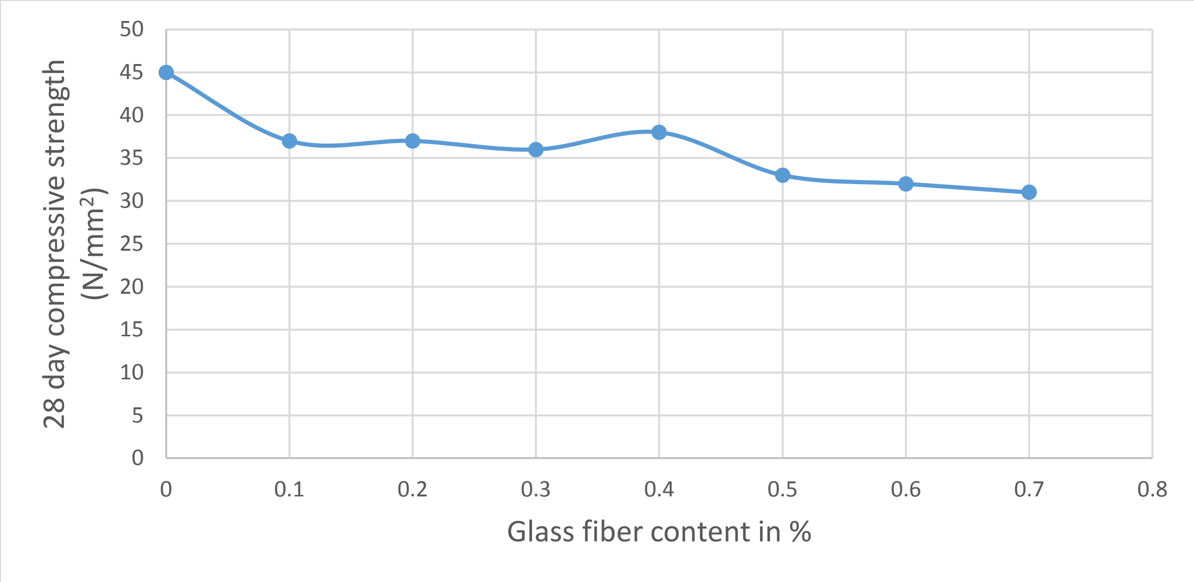

Figure 9 Effect of Glass fibers on 28 days Compressive Strength

5.4.2 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 9 shows the data of 28 days wet transverse strength obtained. Table 9 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 Fig9 overall an increase in the wet transverse strength was observed with addition of fibers.

Table 9 28 days Wet Transverse Strength of Concrete

Fibre content(% of the total weight of concrete)	Average 28 day transverse strength (N/mm^2)
0	1.41
0.1	1.64
0.2	1.72
0.3	1.87

0.4	1.944
0.5	2.24
0.6	2.39
0.7	2.542

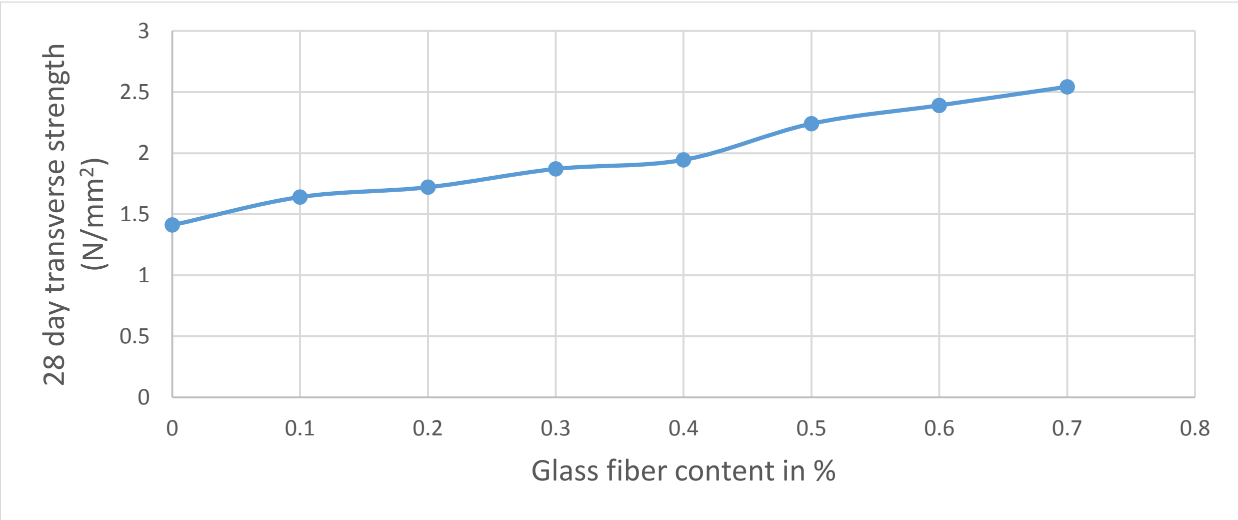

Figure 10 Effect of Glass fibers on 28 days Wet Transverse Strength

5.4.3 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 10 shows the data of 28 days water absorption obtained. Table 10 gives the 28 days water absorption of concrete with maximum nominal size of aggregates 8mm.The 28 days water absorption was also plotted as shown in Fig11 overall decrease in the water absorption was observed with addition of fibers.

Table 10 28 days Water Absorption of Concrete

Fibre content(% of the total weight of concrete)	Average water absorption after 28 days (%)
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
0.7	1.02

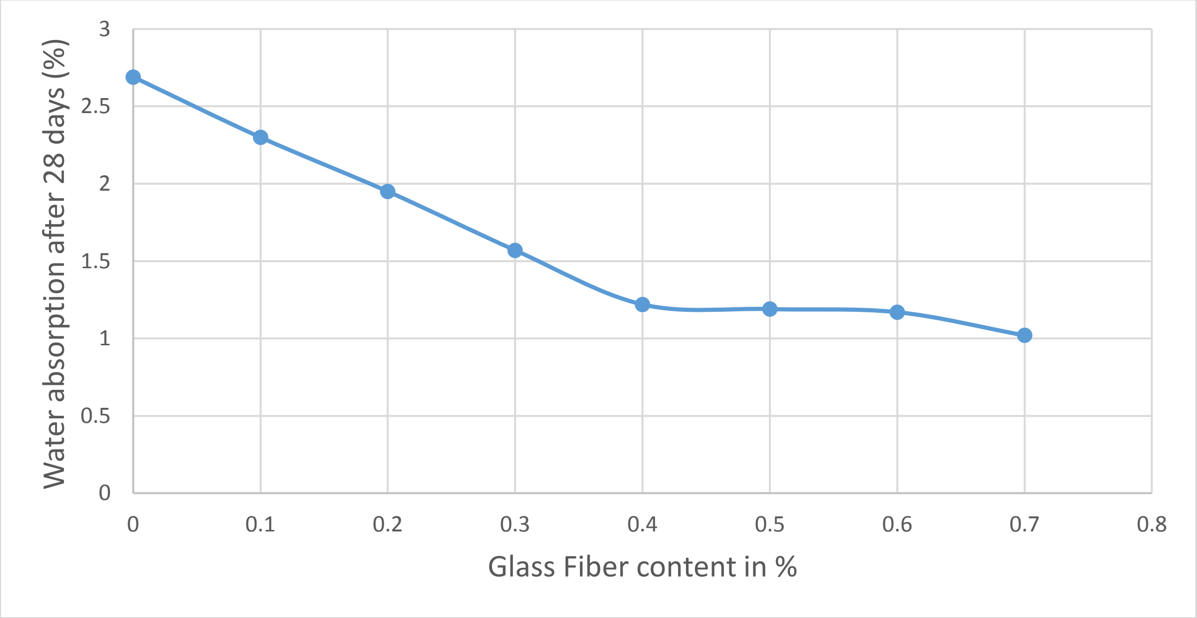

Figure 11 Effect of Glass fibers on 28 days Water absorption of concrete

5.4.4 Pulse 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 11

Table 11 Obtained Pulse velocity

Fibre content(% of the total weight of concrete)	Average velocity(m/s)	Grade of concrete
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

CHAPTER 6

CONCLUSIONS

6 CONCLUSIONS

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 fibres 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 observation based on the experimental result are as follows:

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

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