International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 10 Issue 6 ǁ 2022 ǁ PP. 184-192

Effect of Chopped Glass Fibers On TheStrength Of Concrete Tiles

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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 intoconsideration and no special technique was used to produce this tiles. The thickness of the tileswas 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 alsoconducted.*

Date of Submission: 22-05-2022 Date of acceptance: 04-06-2022

I. INTRODUCTION

General

One of the most important building material is concrete and its use has been ever increasing inthe 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.

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 alkalineresistant as glass fibre are susceptible to alkali which decreases the durability of GFRC. Glassstrands are utilized for the most part for outside claddings, veneer plates and differentcomponents 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 produc 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

II. MATERIALS AND METHODS

Materials

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 followingnominal 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 whereasin 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.

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 ofcement 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 dueto 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 definiteproportion 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.

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 mostregularly 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 coupleof 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 aggregatepassed through 4.75 mm sieve and had a specific gravity of 2.68. The sand belonged to zone III as per IS standards.

Coarse Aggregates

The aggregates the vast majority of which are held on 4.75mm IS sieve and contains just thata 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 partiallycrushed 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.

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 suspensionmedium until the grid has solidified, furthermore it serves as the lubricant between the fine andcoarse aggregates and makes concrete workable.

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 bynature 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 maybe even in form of textile fibres or woven mesh fibres. Various types of fibres have been addedto 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 tocreate 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 oxidesand 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 thengathered 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.

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 offera 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 desireworkability 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.Thesize of the tiles being 400mm*400mm*20mm.The maximum size of aggregates used for 8mmin case of tiles and the testing for tiles were done as per IS 1237:2012.The fibre content variedfrom 0% to 0.7% and the main study of interest was compressive strength, wet transverse strength and water absorption.

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 asto 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 materialseither 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 processfresh 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 machinedrum was cleaned and then moistened so as to prevent any loss of water as we are adding onlya calculated amount and no extra water is added. All the dry materials are put in the drum andthen 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 platefrom where we take it and fill our moulds.

Compaction

All specimens were first filled in their respective moulds and then hand compacted using a rodof 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.

Curing Of Concrete

A significant part of the physical properties of cement rely on upon the degree of hydration ofbond 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 twocategories 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.

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 theconcrete was .The nominal maximum size of aggregate was 20mm and no admixture was used.

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 ofthe mix was observed to come down but however no extra water was used.

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 aresult 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:

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

Tests carried out on Cement and Concrete Tiles

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

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^{0}C 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.

Wet Transverse Strength Test

In order to determine the wet transverse strength of tiles six full sized tiles are tested at 28 daysas 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 surfaceis upwards and its sides parallel to supports. The load is applied in such a way that the steel rodis 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 m

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 pondcuring 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$^{2.}$

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 theconcrete being tested. Comparatively higher velocity is obtained when concrete quality is goodin terms of density, uniformity, homogeneity etc. First couplant is applied to the surfaces of thetransducers 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 readingappears 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)

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 sieveanalysis. 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 dustwas 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 averagedover three cubes was 41.67MPa.

Test on sand

Specific gravity test: The specific gravity of sand was measured using a pycnometer by theprocedure 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 sieveanalysis was carried out. The sieve sizes were as per IS 2386-part I. The zone of sand was zone iii.

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 ofconcrete to a great extent. Maximum .3% chopped fibres by weight of concrete were added tocheck 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.

III. RESULTS

The results obtained are shown below in tabular form

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

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

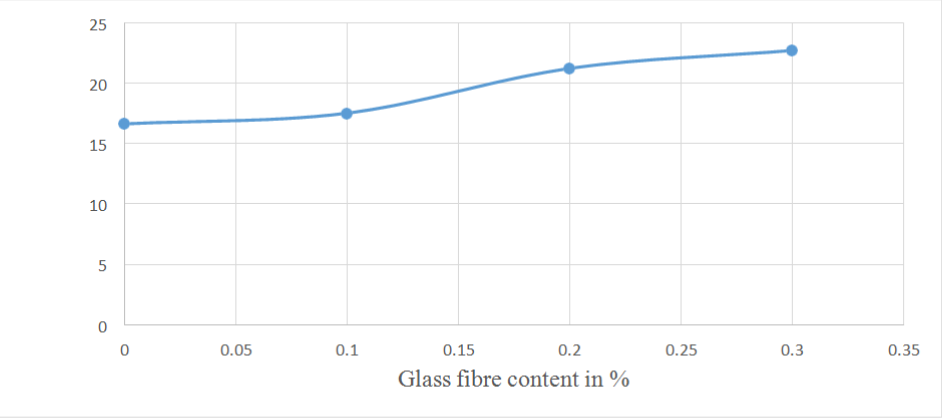


TABLE-2

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

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

The 7 days Split Tensile strength was studied and the values of 3 samples studied are shownin 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

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

Flexural Tensile Strength (in N/mm^2)

The 7 days Flexural Tensile strength was studied and the values of 3 samples studied are shownin the tabular form.Table 5 shows the data of 7 days flexural tensile obtained. Table 5 gives the7 day compressive strength of concrete with maximum nominal size of aggregates 20mm.The7 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

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

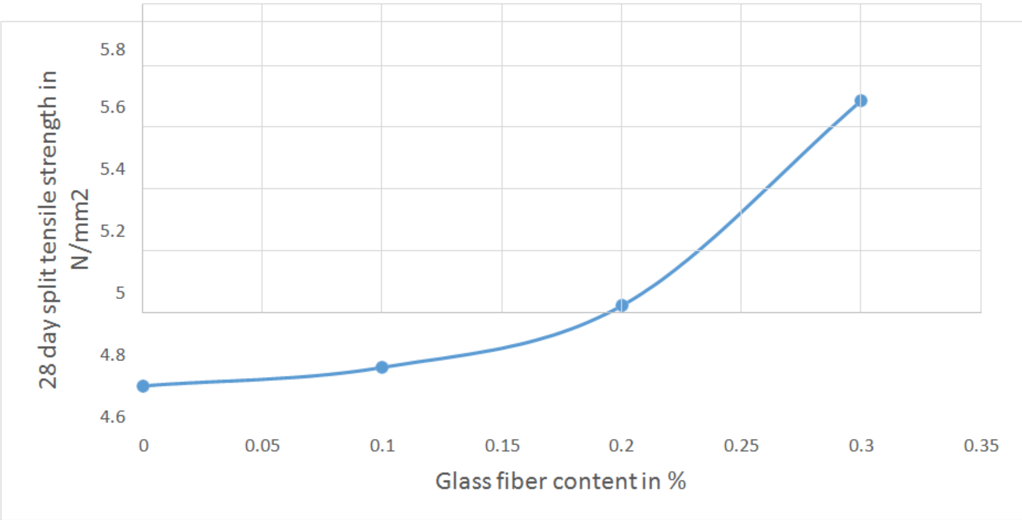
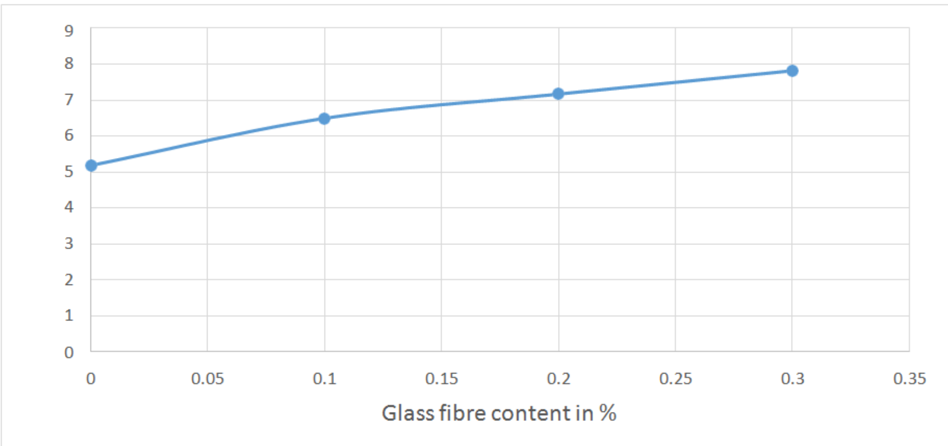


Figure 6 Effect of Glass fibers on 7 days Flexural strength

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 withaddition of fibers.

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



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