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Study on M20 Grade Concrete Strength Analysis by using Glass Fibres

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ABSTRACT

Concrete is among the most crucial building material and its application has been constantly on the rise in the whole world. The reasons for which are that it is comparatively inexpensive and its ingredients are easily accessible, and have application in a wide variety of civil infrastructure work. But concrete has some drawbacks such as brittleness and low crack opening and spread resistance. Concrete has a tendency of brittleness and has very low tensile strength and hence fibres are added in some form or the other to enhance its tensile strength and reduce its brittleness. Over time numerous experiments have been performed for refining the properties of concrete in both fresh condition and hard condition. The fundamental materials are the same but superplasticizer, admixtures, micro fills are also utilized in order to achieve the preferred workability, setting time reduction or reduction 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.

INTRODUCTION

GENERAL

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 affect the properties of GFRC..

Advantages and Disadvantages of using Glass Fibres in Concrete

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 counter top can be1-inch thick with GFRC rather than 2 inches thick when using conventional steel reinforcement.

2. High flexural strength, high strength to weight ratio.

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

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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 40percent 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.

Objectives

The main objective for the present research is defined as follows:

1. To study the compressive strength, split-tensile strength and flexural strength properties of concrete reinforced with short discrete fibers.
2. To analyze the effect of glass fiber on cement and concrete tiles.

Present Investigation

The aim of the present work is to investigate the compressive strength, split tensile strength and flexural strength characteristics of the short discrete fiber reinforced concrete. The work was performed using M- 20 grade of cement, the fiber length of glass was 30 mm and the fiber content was ranging from 0% up to 0.3% of total weight of concrete. No admixture was used in investigating the above said three characteristics. Also the influence of glass fiber on cement and concrete tiles was observed whose fiber content varied ranging from 0% up to 0.7% of total weight of concrete. The cement and concrete are heavy duty tiles which are utilized in many places and of practical application.

LITERATURE REVIEW

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 116 R, 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 durabilityremains 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 dividedFRC broadlyinto 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 ofplates 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 AlkaliResistant 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).

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 beincreased. It has also been observed a 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.

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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 mould. 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.

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.

In organic 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 durabilityaspect 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.

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 coirandsisal 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.

Rheologicalproperties of coir fiber strengthened cement mortar were done byRamakrishna and Sundararajan (2002).Flow value, cohesion and angle of internal strands were presented by Holmer Savastano Jr et al(1998).. Eucalyptus pulp, coir fibres and with a mixture of sisal fibre and eucalyptus pulp gave a suitableperformance 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; incompletesubstitution 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 micro structures and flexural conduct. It was recommended that submersion of common strands in a silica seethe slurry before the

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expansion to the bond based composites was discovered to be an successful method for decreasing embrittlement of thecompositein nature. Additionallyearly cure composites in a CO2- rich environment and the fractional substitution of OPC by undensified silica smoke were the proficient methodologies in getting regular strands with enhanced sturdiness.

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.

In our work Portland slag cement (PSC) -43 grade Konark cement was used. Standard consistency, Initial setting time, Final setting time and 28-day compressive strength tests were carried out as per the Indian standard specifications. Clean river sand passing through 4.75 mm sievewas 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.

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 thereby 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.

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 sizeof 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 fineaggregate used for the experimental programme was obtained from river bed of Koel. The fine aggregatepassedthrough 4.75mmsieveand had a specific gravityof2.68. Thesandbelongedto 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 that a lot of fine material as is allowed by the code specifications are termed as coarseaggregates. 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.

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.

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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 maybe 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.

Compressive Strength of Concrete

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 Figure 1 by taking the average of this three values overall an increase in the compressive strength was observed with addition of fibers.

The 28 days compressive strength was studied and the values of 3 samples studied are shown in thetabularform.Table2 showsthe dataof28days 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 Figure 2 by taking the average of this three values overall an increase in the compressive strength was observed with addition of fibers.

Table 5.2: 28 days compressive strength of concrete (N/mm^2)

S. No.	Without fibre	0.1%fibre	0.2 %	0.3 %
1	25.43	29	28.78	31.12
2	25.87	32	28.78	29.68
3	25.43	29	32	31.66

Split Tensile Strength comparison

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 20 mm.The 7days compressive strength was also plotted Figure3 by taking the average of this three values overall an increase in the compressive strength was observed with addition of fibers.

Table 5.3:7 days split tensile strength of concrete (N/mm^2)

S. No.	Without fibre	0.1%fibre	0.2 %	0.3 %
1	1.495	1.87	2.415	2.415
2	1.636	1.74	2.36	2.415
3	1.46	1.87	2.36	2.273

The 28 days Split Tensile strength was studied and the values of 3 samples studied are shown in thetabularform.Table4 showsthe dataof28days 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 Figure 4 by taking the average of this threevalues overall an increase in thecompressivestrength was observed with addition offibers.

Flexural Tensile Strength

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 the7 day compressive strength of concrete with maximum nominal size of aggregates 20 mm.The 7 days compressive strength was also plotted Figure 5 by taking the average of this three values overall an increase in the compressive strength was observed with addition of fibers.

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Table 5.5: 7 Days Flexural Strength Of Concrete (N/Mm^2)

S. No.	Without fibre	0.1%fibre	0.2 %	0.3 %
1	4.7	4.844	4.998	5.844
2	4.8	4.876	4.998	5.524
3	4.9	4.856	4.9	5.804

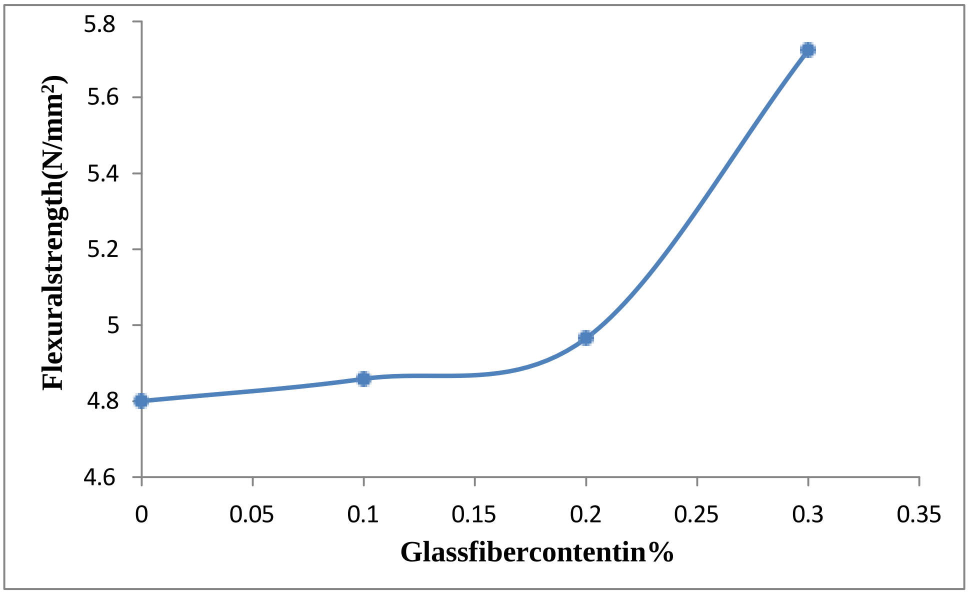

Figure 5.5: Effect of Glassfibers on 7 days flexural strength

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 Figure 6 by taking the average of this three values overall an increase in the compressive strength was observed with addition of fibers.

Table 5.6: 28 days flexural strength of concrete (N/mm^2)

S. No.	Without fibre	0.1%fibre	0.2 %	0.3 %
1	5.108	6.468	7.644	7.256
2	5.208	6.556	7.204	7.86
3	5.252	6.752	6.944	8.42

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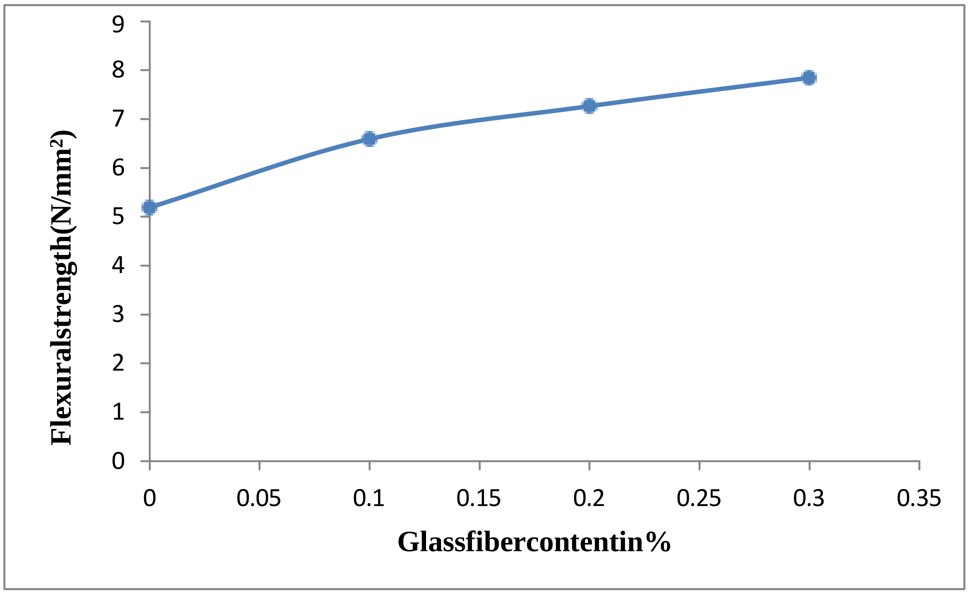

Figure 5.6: Effect of Glassfibers on 28 days flexural strength

Tests carried out on cement and concretetiles

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 frequencytest werealso conducted. The results obtained are given below in tabular form:

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 8 mm. The 7 days compressive strength was also plotted as shown in Figure 7 overall a decrease in the compressive strength was observed with addition of fibers.

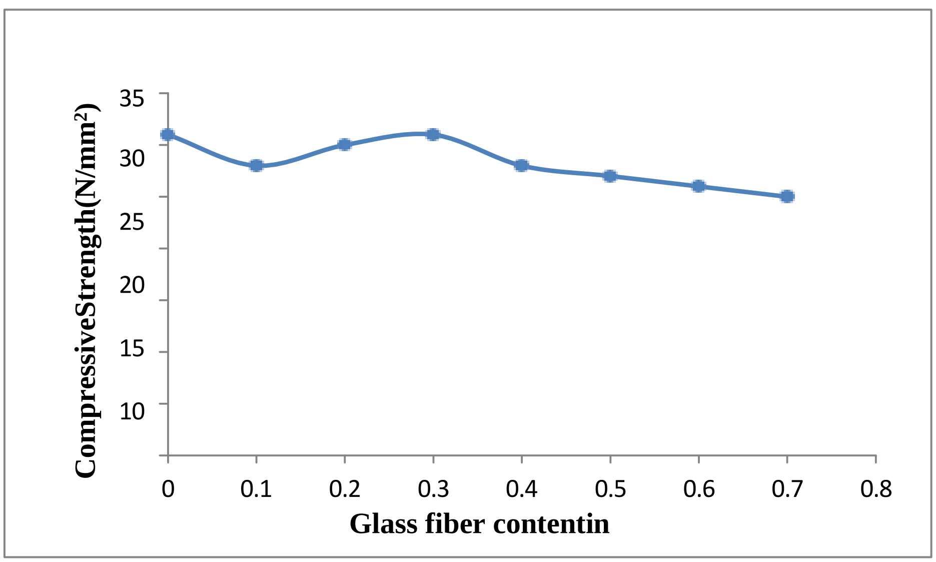

Figure 5.7:Effect of Glass fibers on 7 days compressive strength

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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 Figure 8 overall a decrease in the compressive strength was observed with addition of fibers.

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.

Pulse Velocity test
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.

CONCLUSIONS

The various conclusions 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 .

but decreased with the presence of higher amount of fibers .

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