A Spatial Investigation on Modified Glass Fiber in the Application 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 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.**

***Index Terms*—Glass Fiber, Concrete, Compressive Strength, Tiles, Aggregate.**

I. INTRODUCTION

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.

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.

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 High flexural strength, high strength to weight ratio. Toughness: GFRC doesn't crack easily-it can be cut without chipping. 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. GFRC as a material, however, is much more expensive than conventional concrete on a pound-for-pound basis.

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.

II. LITERATURE REVIEW

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 yearsa 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 work.

III. MATERIALS AND METHODS

a) Materials:- The materials required in the present research work are as follows

- **Concrete**
- **Cement**
- **Fine Aggregates**
- **Coarse Aggregates**
- **Water**
- **Fiber**
- **Admixture**

b) Methodology

The preparation of the tiles was done according to the IS1237:2012 guidelines. We choose a standard size according to the code and this was 400mmx400mmx20mm. We prepare the tiles from a mix containing Portland of Slag Cement and natural of aggregates etc and of after the tiles were cast, we follow it with vibration. These tiles are single in layer and we take good care while preparing them so as to maintain the thickness of the layer at every point and the difference between the thickest and thinnest layer is not more than 10 percent. We prepare the mix by a machine and the mix was then added to the molds one after the other. First, we compact them with a hand, and then they were vibrated using a table vibrator. Surface finishing of these was achieved using a trowel and after they were poured in the molds and the compaction was done as well, we let it settle on the surface and allow it to rest for about 24 hours. Here is a figure for a mold of casting tile.

We define formwork as a kind of momentary or a kind of permanent structure that is used to carry concrete in a fresh condition. The freshly made concrete is plastic in nature and can get into molds easily. Formwork is very essential to form the shape of concrete and also deliver it support while it is attaining enough strength to support the same. The formwork needs to be extremely strong in order to support the dead load and live loads etc. that keep occurring while construction takes place and the concrete should be very rigid as well so that no bulges occur and even sags or twists can be avoided due to the loads. The dead load can be defined as the form weight and even the weight of the concrete that is fresh. While we talk about live weights, it can be the worker weight, runways, machines, and storage materials etc.

In this case, we employ permanent molds and these are normally available in the market. But while preparing the tiles, we especially order the molds and these were obtained from normal shops that fabricate steel.

To get a consistent mix of the products, we do a thorough mixing of the concrete. We can produce in a couple of ways, either we mix it by hand or through a machine. To mix it by hand, we need a leveled surface like a wooden platform or even a surface that is paced and has tighter joints to lessen the loss of paste. While mixing, we first clean the surface, and then it gets moistened. We then pour sand on this surface and then it is the turn of cement on the sand. We mix both these things extremely well. When cement gets mixed well with the sand, we spread a layer of coarse aggregates over this mix and then it is mixed really well again. In order to mix it well we either use a D-handled shovel or a hoe. This mixture is mixed until we get a uniform color. When we get a uniform color of the mixture, we slowly add water to it and the mixture is turned up and down at least thrice when the complete mixing process of the fresh concrete takes place and this concrete is plastic, ready to be entered into the mold according to our needs.

All the samples were poured in their molds and we first do the hand compaction with a rod of about 30mm in dia. The tamping is done in 3 layers and we tamp 20 times on these layers. In order to get complete compaction of, the models were then of vibrated using a vibrator table. We design the tiles by adding the concrete to the molds and then pushing it with our hands with the use of a plain wooden block. We then hold it tight in our hands and then vibrate the same on a vibration table. The surface could be leveled, made smooth, and finished with metal trowels.

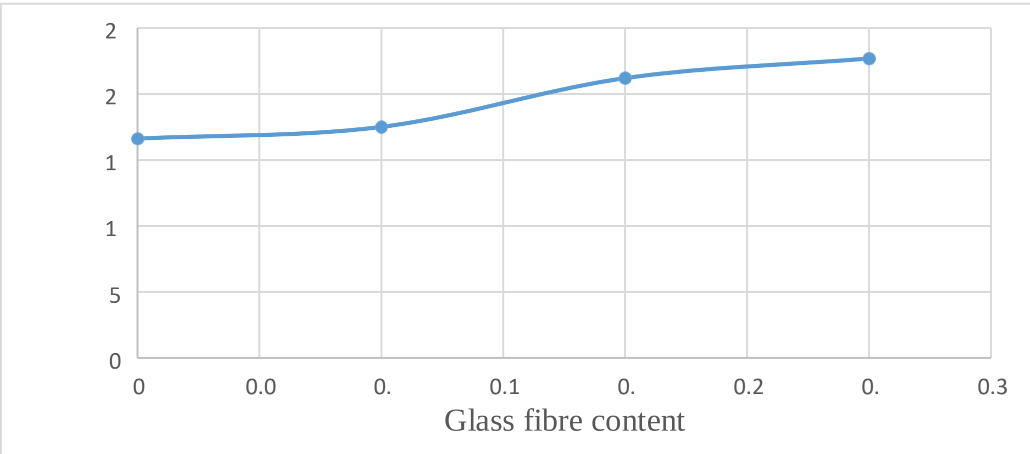
An important aspect in terms of the physical features of concrete depends on the amount of hydration within the bond and the resulting structure of the concrete that is hydrated. Due to this, we see a random 3D structure which takes place of the space that had water. The cement that gets hard is porous in structure and you can categorize the pores into two types which are capillary pores and gel pores. Cement hydration occurs when capillary pores get saturation. It is important to cure the concrete to make it more durable, impermeable, frost-resistant, strong and abrasion-resistant as well. We do curing by a spray of water or through a pond or when it is kept packed in gunny bags that are moist so that moisture loss can be prevented from inside and from the surface. Curing can get started when the concrete can get finally set. As per the rule, the curing should be done at least for 14 days to get about 90 percent of the strength and in our experiment, we use the pond curing method for all the samples, even the tiles.

IV. RESULTS

Results for compressive strength test

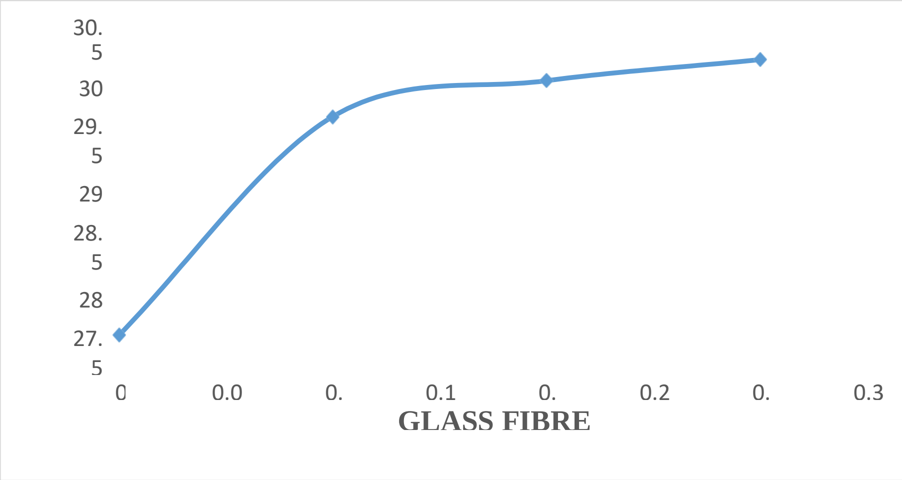
- **7days compressive strength of concrete**

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



- ***28 days compressive strength of concrete***

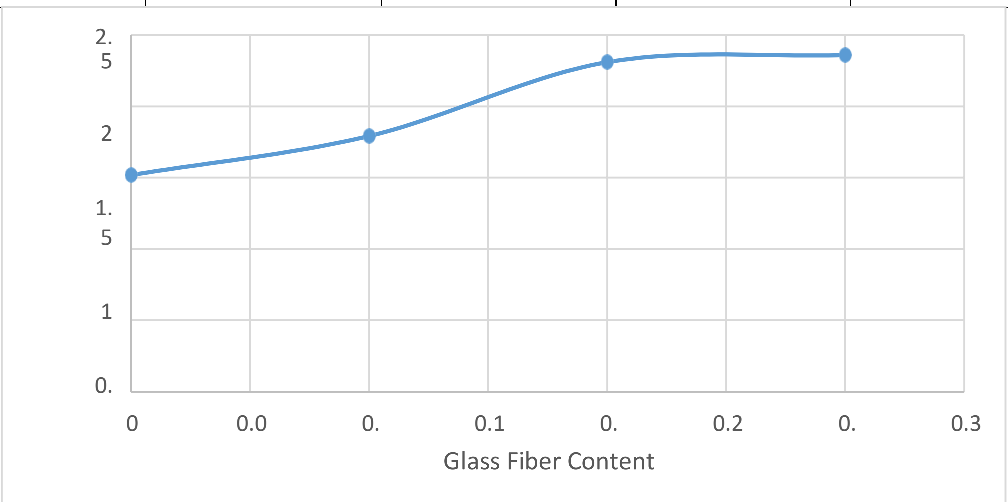
Serial number	Without fibre	0.1%	0.2%	0.3%
1	25.33	28	28.88	30.22
2	25.77	31	28.88	28.88
3	25.33	28	31	30.66



Result for split tensile strength test

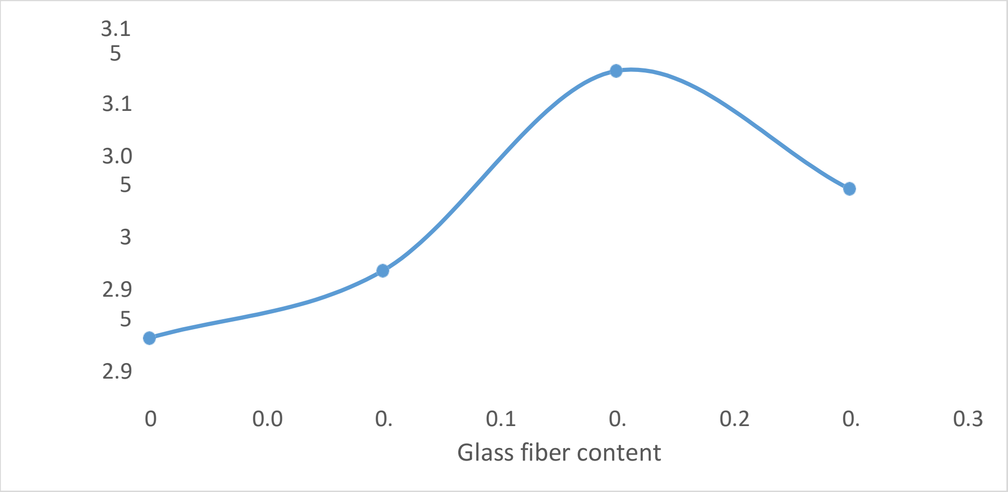
- ***7days Split Tensile Strength of Concrete***

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



- ***28 days Split Tensile Strength of Concrete***

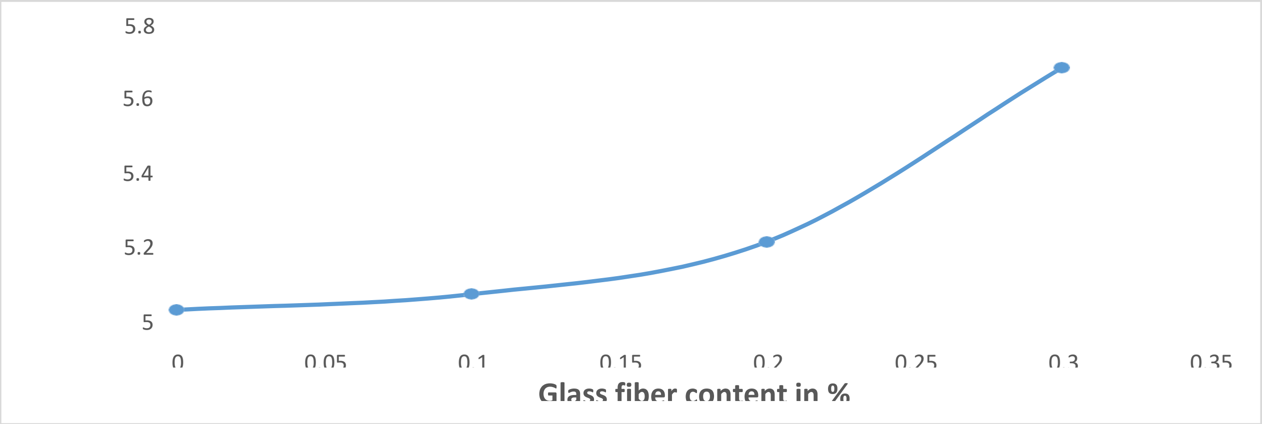
Serial number	Without fibre	0.1%	0.2%	0.3%
1	2.829	2.83	2.97	2.97
2	2.76	2.83	2.97	2.97
3	2.829	2.97	3.35	2.97



Result for Flexural Tensile Strength

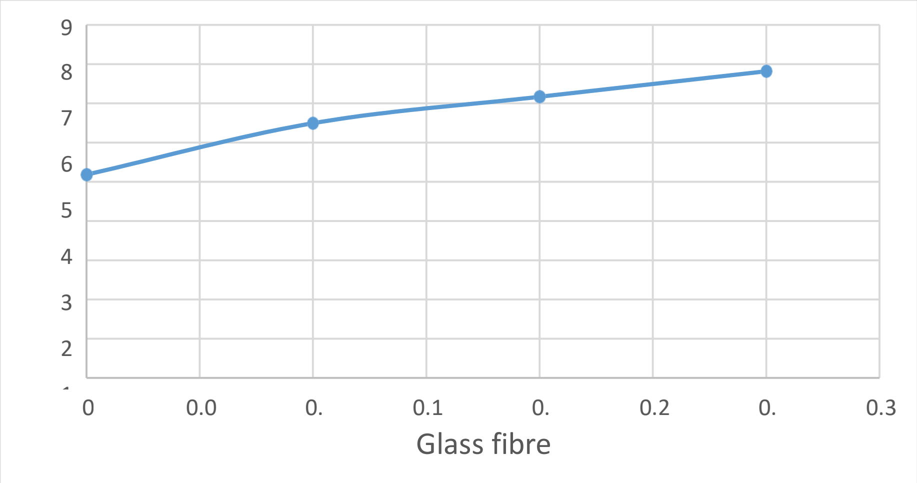
- ***7 days Flexural Strength of Concrete***

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



- ***28 days Flexural Strength of Concrete***

Serial number	Without fiber	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



Result for Concrete Tiles testing

a) **Compressive Strength**

- *7 days Compressive Strength of Concrete*

Fibre content	**Weight**	**Average**
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

- *28 days Compressive Strength of Concrete*

Fiber content	Weight	Average
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

b) **Water Absorption**

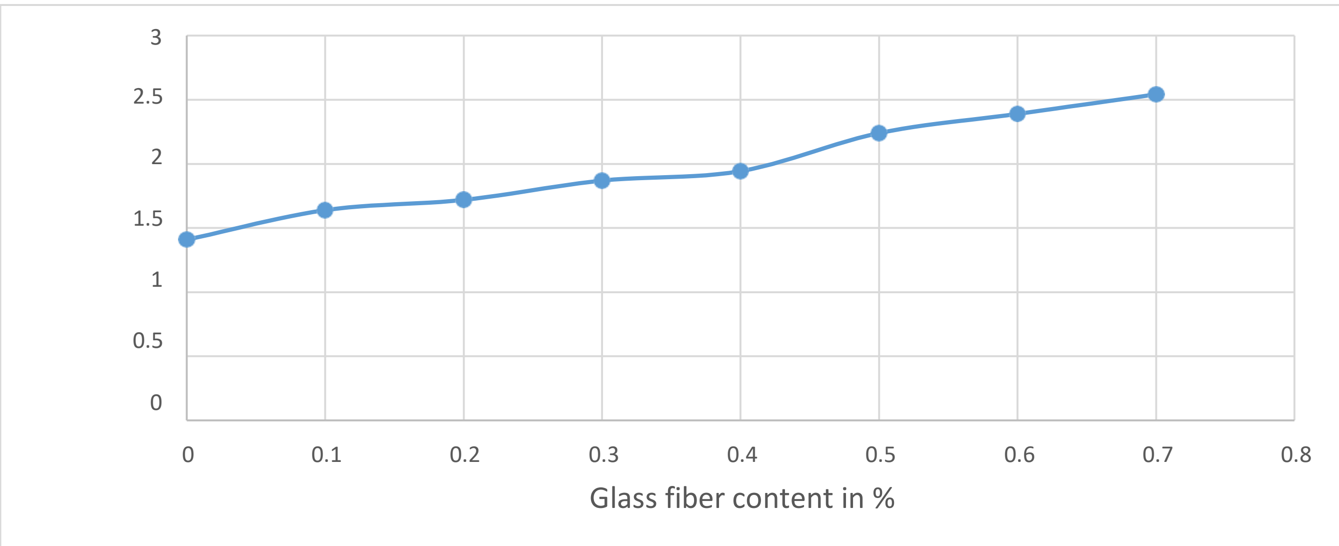
- *28 days Water Absorption of Concrete*

Fibre content	Average water absorption
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

c) Pulse Velocity test

Fibre content	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

d) Wet transverse strength



V. CONCLUSIONS

The observations we get according to the experiments are as below:

1. The concrete compressive strength away from the admixture use does not get affected because of the existence of short and discrete fibers of glass where the content of the fibers ranges from 0.1 percent to 0.3 percent of the content of fiber by the concrete weight.
2. The split tensile strength of concrete can get increased for concrete when we add glass fibers.
3. The flexural strength may see an increment in concrete when the fiber content was increased and in this case, the capacity to carry tension for concrete may get increased.
4. Tiles' wet transverse strength can increase and the increment was found due to fiber addition.
5. The absorption of water also sees a decrement when the fiber content was increased.
6. Concrete's compressive strength with the use of admixtures was never affected with up to 0.4 percent of fiber content but it may get decreased with the content of fiber when increased.

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