Effect of Glass Fiber on Strength and Durability of Concrete

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Abstract - *Concrete is a major product which is widely used in every construction site and being used as per strength required for the given element of structure. The modern scenario the concrete industry is towards gaining more strength and durability of concrete to meet the demands of the current construction works. Hence, Varieties of admixtures has been used so far to improve its properties, i.e. Compressive strength, Split Tensile strength & durability etc. There has been a substantial growth in the use of glass fibre in concrete for refining its properties such as Compressive strength, tensile strength and durability that is the reason why the glass fibre concrete is generally used in concrete and mortar for retrofitting in present concrete structures.*

Hence, In this studies we attempt to investigation the effect of glass fibre in concrete with different variations of 0%, 0.25%, 0.5%, 0.75%, 1.0% & 1.5% to determine the effect in its properties such as Compressive strength, Split tensile Strength and durability. The cubes were cured in ordinary tap water and the solution of Sulphuric acid of N/50 Normality also.

Key Words: *Concrete, Glass fibre, Compressive strength, Split tensile strength, Cured, Sulphuric acid.*

1. INTRODUCTION

Concrete is a major product in field of civil engineering to construct structure & its demand is up surging day by day. It is a second most used item in the world after water. Nowadays, Structures are getting complex, So, We have to develop better products which are more reliable and stronger which help in making thin structural frames and making structure economical where development of any product is a major aspect in any field. Various fibers are usually used in concrete for prevent of drying, shrinkage, cracking and plastic shrinkage cracking which gives them a plus point to it. Some fibers generate higher resistance to impact, shatter and abrasion in the concrete which is remarkably good. Moreover, they also lower down the penetration as well as permeability in concrete which at last leads to the diminishing the bleeding of water. Fibers are thin or small piece of reinforcing component for concrete, possessing certain characteristics. Low fibre content up to 0.3% of concrete mix has found effective in floor slab application.

GFRC is an improved form of conventional concrete. It is a fusion of cement, fine sand, water, Coarse aggregate, admixtures and glass fibre in which short length glass fibers are dispersed. Glass fibre opts good resistance for tension which is the reason why Glass fibre is chosen as reinforcement for concrete industries. Glass fibre is a featherweight and impressively strong substance which improve the property of concrete [10]. The tensile strength of concrete is pretty much less as compares to its compressive strength, The effect of the fibers in this composite leads to growth the mechanical properties of concrete and mortar [1]. FRC is a form multipurpose building construction material which has been available to construction industry. The rising demand in composite product having glass fibre. Due to this , the annual market has been reached an turnover in 1000 of millions USD annually [23] Compared to ordinary Portland concrete, it has a bit different properties because of its special structure. Different parameters such as water–cement ratio, void ratio(porosity), product density, inter filler content, substantial content, orientation length of fibre & technique of cure affect the properties and performance of GFRC as well as precision of production method are also an aspect [12].

2. Literature Review

The present scenario in concrete industry is in the direction of growing the strength and durability of concrete to meet the demands of the present construction world at minimal cost. These factors can be achieved in concrete by mixing desirable natural or artificial fiber. In the research by K. Chawla and B. Tekwani [5] observed the AR-GFRC filaments and detailed that the ideal amount of GF that should be mix in concrete is 0.33% of the total mixture weight of product to improve its property. Likewise, they notice that this amount of GF rise the compressive resistance and the flexural strength by 36.7% and 129.15 % compared to the conventional concrete respectively after 28 days of curing.

On the other hand, In 2016, Kariappa et al. [18] experiment on concrete grade of M20 in which he find that the presence of 0.4% to its total mixture weight ARGF filaments caused in the maximum resistance values in mechanical properties such as the flexural, compressive and tensile strengths, and the increase rate gaining to 33.21%, 54% and 58.24%, respectively after curing for 28 days. In study of Glass fibre reinforced polymer specimens retrofitted the flexural strength was increased up to 23% in extreme heat exposure where ordinary concrete losses its strength up to 23%.C. Selin Ravikumar and T.S. Thandavamoorthy [17] observed a noticeable growth in the use of fibers in concrete for enhancing its properties such as tensile strength and ductility that is reason the fiber concrete is commonly used in retrofitting in modern structures for better and improved aesthetic appearance. Nevertheless, GFRC is a recent introduction in the field of concrete industry.

In study of reinforced shear walls, the dosage about 0.3 % of alkali-resistant glass fibre enhancing best ductility on the specimen .Nevertheless when the content was about 0.4 % indicate inadequate effects on the postponing of the bearing capacity degradation of the model [24]. In addition of that,the thermal conductivity under high temperature is reduced by adding Glass fibre having a longitudinal length of 0.6 cm with increasing amount of glass fibre and if the length of the glass fibre will be increase the thermal conductivity was founded reduced [25].

The GFRC was used on Telecommunication tower with carbon fiber and in the observation I was found the weight of the structure reduced and better durability were observed. In the outcome the average mean values were: 41 MPa in compression strength, 3.7 MPa in tension strength & initial Young modulus was 16.5 GPa. [11]. GFRC displayed noteworthy performance on fire resistance, since the use of GFRCs is for architectural building panels. In these buildings, fire resistance becomes an important aspect in design of the structure.

3. Materials & Methodology

3.1 Cement

The cement which is used for project was OPC of 43 grade manufactured by Ambuja cement had a manufacturing in 3rd week of January 2022 and generally available in local market .In examination of cement the material was found fit for use as per IS 8112 and having a specific gravity of 3.14

Table -1: Properties of Cement

S. No.	Test	Any specification	Observed Value	Requirement as Per IS :269-2015	Conformity
1	Fineness	Is:4031(Part-2)	0.69 %	Less than 10%	Yes
2	Setting Time (Minutes)	IS:4031(Part-5)			
A	Initial		136	30min.	Yes
B	Final		262	600 Max.	Yes
3	Soundness (mm)	IS:4031(Part-3)			
(A)	Le- Chatelier		3mm	10mm max.	Yes
4	Compressive Strength(N/mm^2)	IS:4031(Part-6)			
(B)	7 Days		38	33.00 Min	Yes
(C)	28 Days		48	43.0 Min	Yes

3.2 Sand

We used river sand as fine aggregate whose source is from Kothputli which is locally available in market of zone II category as per IS 383, it was free from deleterious materials & having the specific gravity of sand was 2.68.

Table -2: Properties of Sand

S. No.	Name of Parameters	Observed Value	Test as Per IS:	Requirement as Per IS 383:2016
1	Specific Gravity	2.68	2386(Part. 3)1963	
2	Water absorption (%)	2.46	2386(Part-3)1963	
3	Deleterious Materials			
A	Coal & Lignite (%)	Nil	2386(Part-2)1964	1.00max.
B	Clays and Lumps	Nil	2386(Part. 2)1963	1.00max.
C	Silt content	5.6	2386(Part-1)1963	15.00max.
D	Total %Of All Deleterious Materials	Nil	2386(Part. 5)1963	2.00max.
6	Sieve Analysis (%)	-	2386(Part-7)1963	

Table 3 Sieve Analysis of Sand

Sieve Size	% of passing			Average passing in %	Is Limit 383-2016 Zone-II
	Sample One	Sample 2	Sample 3		
4.75	0	0	0	0	90-100
2.36	94.3	96.6	93.7	94.9	75-100
1.18	76.8	72.9	70.7	73.8	55-90
600	56.2	57.9	58.3	57.4	35-59
300	20.6	16.4	17.3	18.1	8-30
150	6.2	3.7	7.6	5.8	0-10

3.3 Coarse aggregate

We used crushed angular particles whose source was Kothputli (Rajasthan) which is locally available in market and free from deleterious materials The specific gravity was 2.70, the coarse aggregate used have 60% of 20mm aggregate and 40% of 10mm aggregate proportion in total coarse aggregate.

Table 4 Properties of Coarse Aggregate

S. No.	Test	Observed Value	Test Method As Per IS:	Requirement As Per Is :383-2016
1	Specific Gravity	2.70	2386(Part-3)	
2	Organic Matter	Nil	2386(Part-2)	
3	Water Absorption	2.53	2386(Part-3)	
4	Flakiness Index (%) and elongation index(%)	12.6	2386(Part-1)	Max 40%
5	Deleterious Materials			
(A)	Material Finer Than 75 Micron (%)	0.08	2386(Part-1)	1.0 Max.
(B)	Clay & Lump (%)	Nil	2386(Part-2)	1.0 Max.
(C)	Coal & Lignite	Nil	2386(Part-2)	1.0 Max.
(D)	Soft Fragment	Nil	2386(Part-2)	3.0 Max.
	Total Deleterious Materials	0.08	2386(Part-2)	2.0 Max.
6	Impact Value (%)	19.5	2386(Part-4)	30 Max. Wearing Surface
7	Moisture content (%)	0.14	2386(part-3)	Max 3 %

Table 5 Sieve Analysis of 20 mm Aggregate

Sieve Size	Percentage Passing			Average Percentage Passing	Limit As Per IS:383:2016
	Sample 1	Sample 2	Sample 3		
25mm	100	100	100	100	100
20mm	96.55	91.74	92.81	93.69	85 To 100
10mm	5.58	6.74	7.26	6.50	0 To 20
4.75mm	0.13	0.26	0.24	0.21	0 To 5
Pan	0.14	0.04	0.06	0.08	

3.4 Water

The tap water of collage used in the project was within the permissible limit as per recommendations of IS 456-2000.

S. no.	Type of tests	Result	Permissible limit as per IS 456:2000
1	Volume of 0.02 N H_2SO_4 required to neutralize 100ml sample using mixed indicator	21.6	Max 25 ml
2	Volume of 0.02 N NaOH required to neutralize 100ml sample using phenolphthalein indicator	1.7	Max 5ml
3	Organic solid (mg/l)	82	Max. 200mg/l
4	Inorganic solids (mg/l)	622	Max. 3000mg/l
5	Sulphates as SO_4 (mg/l)	84	Max. 400mg/l
6	Chlorides (mg/l)	120	Max. 2000 mg/l
7	Suspended matter (mg/l)	Negligible	Max.2000 mg/l
8	PH level	7.6	Not less than 6

3.5 Glass Fibre

We get the glass fibre from local ware house in Delhi where they curtail the fibre as per desired length of 50.8 mm which having diameter of 14 microns.

4. Methodology

The proportion for the mix design was 0.40: 1: 1.84: 3.31 [Water: cement: F.A.: C.A] with variation of dosage of 0, 0.25, 0.5, 0.75, 1.0 & 1.5 % with respect of weight of cement where the proportion of the ingredients mix design was calculated by per IS 10262:2016.

The Sulphuric acid of Normality of N/50 was prepared by diluting the 98 % concentrated H2SO4 in water in proportion or dosage of 55.14 ml per 10 litre of water with testing (normalising with Na2OH 10 ml and phenolphthalein (C20H14O4) indicator).

The Compressive Strength test was conducted on the cube specimen 15cm of Cast iron moulds were used to cast the cubes having leak proof metal base plate. The Split tensile strength test was conducted on the cylindrical specimen diameter of 150mm and 300mm in length.

During the pouring the concrete into moulds the vibrating table and tamping rod were used to compact the concrete each time, the moulds were well polished with shuttering oil before the pouring and after the removing of specimen from the mould. The specimens were marked with date of manufacturing and percentage of fibres.

The specimens were cured with tap water and H2SO4 water solution of 0.02 normality for 7 and 28 days. The Non-destructive test like UPVT and Rebound hammer test were conducted on the cubical and cylindrical specimens.The surface of specimen were rubbed with porous stones to perform UPVT by direct method. On the other hand, the Rebound numbers of specimens get by rebound hammer in which the point of impacts were more than 15 mm away from its corner.

The temperature during the blending the ingredient was nearly 26°C.The Compressive strength and Split tensile strength were performed with compressive testing machine which having capacity of 2MN where the load was increasing gradually.

5. Results & Discussion

5.1 Properties of Green concrete

There were no noticeable change in wet concrete properties such as slump value of concrete and its temperature with variation of percentage of fibre during the experiments. The concrete having a low slump value which did not vary and the temperature of concrete was also did not change in such magnitude.

Table 7 Slump and Temperature Of Green Concrete

Fibre content(%)	Slump value in mm	Temperature in °C
0	15	30.3
0.25	13	30.5
0.50	15	30.5
0.75	12	30.6
1.0	15	30.8
1.5	18	30.3

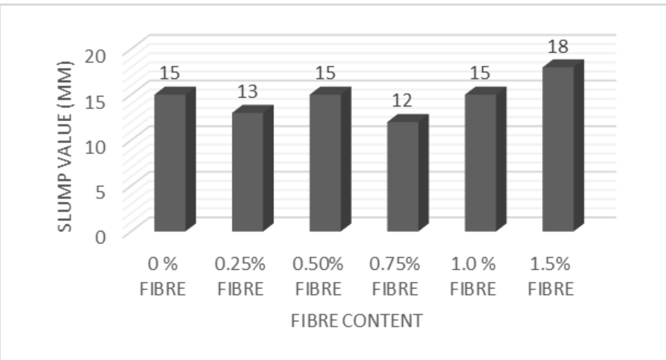

Figure 1 slump value of mixes (in mm)

5.2 Properties of Harden concrete

5.2.1 Compressive strength

Overall, There was a reduction in compressive strength when the percentage of fibre in cubes where 0.25 & 0.5 after that extent there was growth in strength in case of normal water curing as well as acid water curing (H2SO4 of N/50).

There was 6.92%,10.42%,11.53%,7.03%,9.11% & 4.44% of compressive strength was increased in acid cuing for 0,0.25,0.5,0.75,1.0 &1.5 respectively % of glass fibre content for the 7 days specimens .However, In same manners after examine the specimen of 28 days it was found that the Compressive was decreased nearly 1.08%,5.20%,2.14%,1.55%,4.59% & 5.35%.

The compressive strength was decrease for specimen which having 0.25% and 0.5 % of glass fibre content in every case with respect of age of concrete. In addition of that for 1.0% and 1.5 glass fibers specimens had get increase in strength which were 1.6% and 7.37% for normal curing condition, 3.84 and 4.88% for acid curing after 7 days. Furthermore, there was 13.88% and 18.99% % for normal curing condition, 9.70% and 13.70% for acid curing after 28 days.

Table 8 Compressive strength of concrete cubes with normal and acid curing conditions.

Fibre content (%)	Normal curing 7 days (N/mm²)	Normal curing 28 days (N/mm²)	Acid curing 7 days (N/mm²)	Acid curing 28 days (N/mm²)
0	43.16	49.14	46.15	48.67
0.25	37.33	48.42	40.23	45.90
0.50	31.65	42.94	35.30	42.02
0.75	42.66	53.50	45.08	52.67
1.0	43.89	55.96	47.92	53.39
1.5	46.34	58.47	48.40	55.34

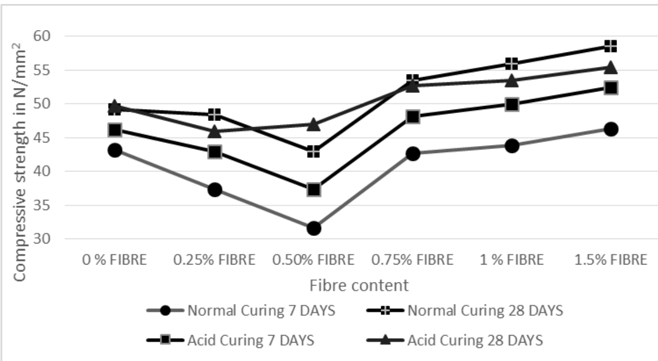

Figure 2 Comparison of compressive strength after 7 & 28 days with normal and acid curing condition

5.2.2 Split Tensile Strength

The tensile strength was follow same trend where the strength of glass fibre specimens having 0.5% content having lower strength as compare to 0% of glass fibre specimens. Nevertheless, the split tensile strength was roughly around 10 % of its compressive strength & increased upto 20% at 1.5 % of Glass fibre content.

Table 9 Split tensile strength of cylinders after 28 days

Fibre content (%)	Average mean Load at failure (KN)	Split Tensile Strength in N/mm²
0	333.3333	4.716
0.25	317.000	4.485
0.50	327.9333	4.639
0.75	381.9333	5.403
1 .0	408.4333	5.778
1.5	406.1667	5.746

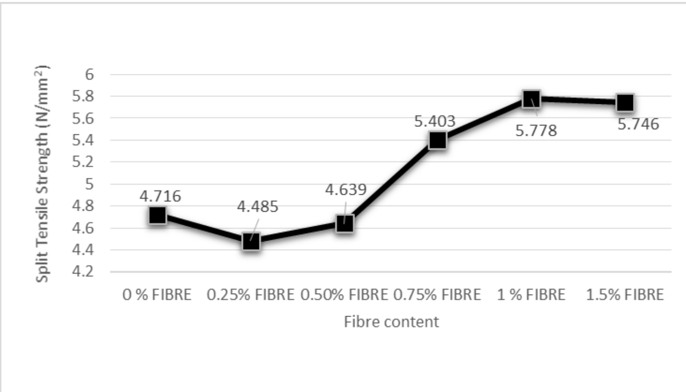

Figure 3 Comparison of Split tensile strength of cylinders with variation of fibre content.

5.2.3 Ultra Sonic Pulse Velocity Test

The ultra-sonic pulse velocity of cubes and cylinder was between 4.25-4.53 Km/s which define as good to Excellent Concrete quality Grading as per IS 13311(part 1):1992.

Table 10 UPVT of Cubes and Cylinders

Fibre Content (%)	Average velocity of Cubes with Normal curing specimens(km/sec)	Average velocity of Cubes with Acid curing specimens(km/sec)	Average velocity of Cylindrical specimens (km/sec)
0	4.53	4.48	4.51
0.25	4.25	4.33	4.45
0.50	4.32	4.36	4.41
0.75	4.37	4.38	4.46
1.0	4.47	4.20	4.45
1.5	4.37	4.28	4.46

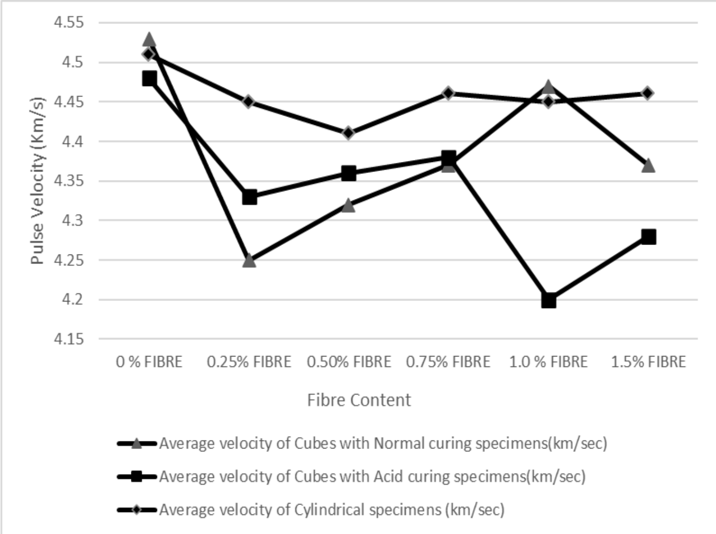

Figure 4 Comparison of pulse velocity of cubes and cylinders with variation of fibre content

5.2.4 Rebound Hammer Test

There was no noticeable variation with respect to variation in concrete. However, the quality surface was recognized as very good hard layer as per IS 13311 (2)-1992.

Table 11 Rebound number of cubes (acid and normal curing after 28 days) and cylinders

Fibre content (%)	Mean value of rebound number of cube normal curing 28 days	Mean value of rebound number of cube acid curing 28 days	Mean value of rebound number on cylinders after 28 days
0	46.25	46.22	45.06
0.25	44.17	45.02	43.32
0.50	44.49	43.82	42.35
0.75	46.37	48.43	48.34
1.0	49.9	48.58	51.22
1.5	50.28	49.75	51.55

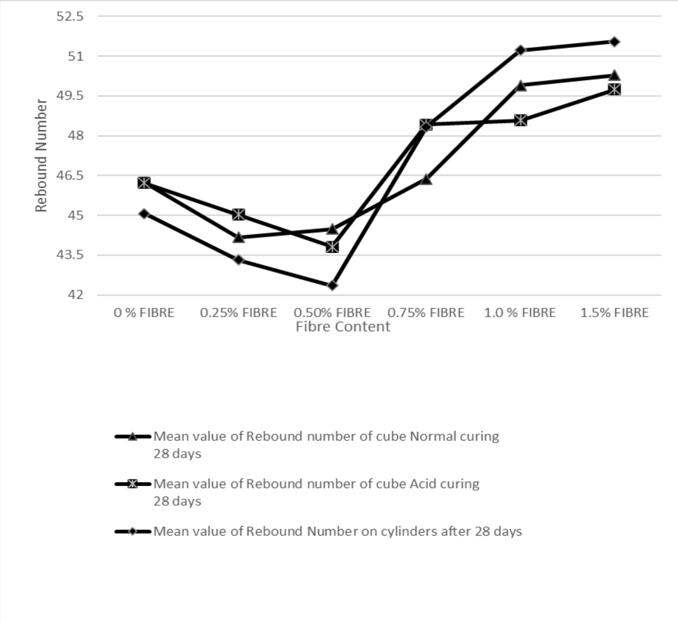

Figure 5 Comparison of rebound number with fibre content

5.2.5 Relationship between Compressive strength and Split-tensile strength

The given figure shows the relationship between the split tensile strength and compressive strength of mix design and it was found that an equation developed which for 0%,0.75%,1.0% & 1.5% of fibre content. This equation is y=0.1177x-0.9679. this equation is based upon linear assumption, where slope is 0.1177, intercept is -0.7679, y is Split tensile strength and x is compressive strength of design mix.

Table no.12 Relationship between Compressive strength and Split-tensile strength

Fibre content (%)	Compressive strength of cubes after 28 days (normal curing)	Split tensile strength of cylinders after 28 days (normal curing)
0	49.14	4.716
0.75	53.5	5.43
1.0	55.96	5.778
1.5	58.47	5.746

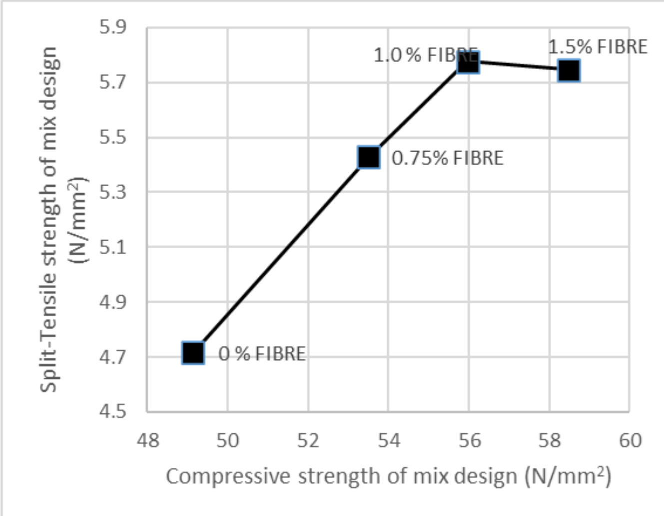

Figure 6 relationship between compressive strength with tensile strength of different variation in fibre content.

5.2.6 Normality of water

There is no noticeable outcome with respect to percentage of fibre in concrete as same manner with respect to age of concrete there is no clear think occurs, Overall, the reduction was about 11-39.5%.

Table 12 Normality of water used for acid curing

Fibre content (%)	Week 1	Week 2	Week 3	WEEK 4
0	0.0121	0.0146	0.0142	0.0134
0.25	0.0178	0.0178	0.0156	0.0140
0.50	0.0138	0.0146	0.0136	0.0132
0.75	0.0178	0.0155	0.0121	0.0129
1.0	0.0164	0.0148	0.0121	0.0158
1.5	0.0138	0.0125	0.0125	0.0138

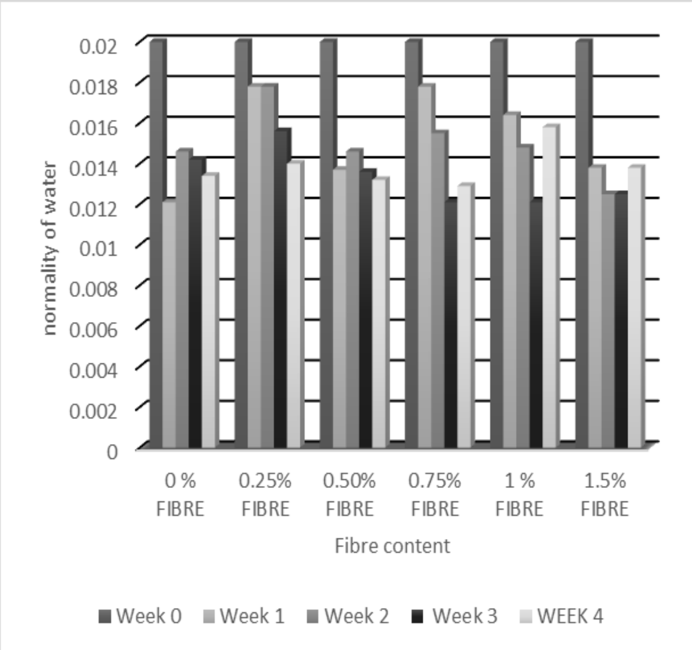

Figure 7 Variation of normality of after every week

6. Conclusion

In the conclusion of this report with the referring the data occurring in the result these are specific things are to be enlighten in the conclusion of the study:-

I. The compressive strength of concrete had decreased when the extent of amount of Glass Fibre was lower than 0.5% of Cement content. In contrast, the specimens had 1.0 % and 1.5 % given noticeable increment in compressive strength nearly 1.6% and 7.37% for normal curing condition, after 7 days. Furthermore, there was 13.88% and 18.99% % for normal curing condition after 28 days.

II. On the other hand, the specimens had 1.0 % and 1.5 % given noticeable increment in compressive strength nearly 3.84 and 4.88% for acid curing after 7 days , for normal curing condition, 9.70% and 13.70% for acid curing after 28 days.

III. The split tensile strength shows similar fashion having about 10 % of its compressive strength.

IV. The pulse velocity by cross probe was4.25-4.53 km/s which is defines the quality grading was good to very good as per IS 113311(2).

V. Normality of water during acid curing were diminish around 11-39.5% where there is no significant was noted to conclude that the effect of reaction with specimens.

VI. There is no significance effect on slump and temperature of concrete with variation of glass fibre which is low.

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