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EXPERIMENTAL STUDY ON EFFECTS OF FIBERGLASS AND FIBER WASTE IN CONCRETE MIXES

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ABSTRACT
In this research concrete mixes were tested to investigate the effect of fiber waste and fiber glass and evaluate the efficiency on fresh and hardened concrete for trying to produce a concrete with high strength. an experimental study was carried out to test for compressive strength of concrete for six types of concrete mixes each mixture were casted in the form of cubes were studied for 7 and 28 days, one of those mentioned mixes is a (control mix). Finally the results are compared with the normal conventional concrete (control mix). The main aim of this investigation is first to prepare the strength of concrete of compressive strength 25N/mm^2 with locally available ingredient and then to study the effect of different proportion of fiber waste and fiber glass in the mix and to find the optimum range of the effective proportion. The various proportions considered are 0.1%, 0.2%, 0.3%, o.4%, o.5% of fiber glass and fiber waste from mixture weight respectively. the research was shown that the effect of fiber and fiber waste on the fresh concrete that the workability decreases as the proportion of the fiber waste and fiber glass additives increases, and for the hardened concrete the specific compressive strength increases up to 0.3% of the fiber waste and fiber glass content of mixture weight, and also show's beyond these mention proportioned that the compressive strength decreases.

KEYWORDS: Concrete, Fiberglass, Fiber waste, Compressive strength.

INTRODUCTION
Concrete is the second largest material consumed by human beings after food and water. It is obtained by mixing cement, fine aggregate, coarse aggregate and water in required proportions. The mixture when placed in forms and allowed to cure becomes hard like stone. The hardening is caused by chemical Action between water and the cement due to which concrete grows stronger with age.[1] Communities around the world rely on concrete as a safe, strong and simple building material. It is used in all types of buildings (from residential to multistory office blocks) and in Infrastructure projects (roads, bridges, etc). Despite its widespread use, many people are unaware of the considerations involved in providing high quality, strong, durable concrete.
In recent year, environmental issues have driven interest to utilize industrial by-product as alternative construction material Disposal of different waste materials produced from various industries is a serious problem. The wastes pose environmental pollution problems for the surrounding disposal area because some of the wastes are not biodegradable. The utilization of industrial wastes in construction has been of great interest in industrialized and developing countries during recent years. Such utilizations are commonly based on technical, economical, and ecological considerations. Lack of conventional materials and improvement of the environment renders it imperative to search for substitutions, including that of industrial wastes.
Fiber Reinforced Concrete: Concrete is the most heavily used construction material in the world. However, it has low tensile strength, low ductility, and low energy absorption. An intrinsic cause of the poor tensile behavior of concrete is its low toughness and the presence of defects. Therefore improving concrete toughness and reducing the size and amount of defects in concrete would lead to better concrete performance. An effective way

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to improve the toughness of concrete is by adding a small fraction (usually 0.5-2% by volume) of short fibers to the concrete mix during mixing. In the fracture process of fiber reinforced concrete (FRC), fibers bridging the cracks in the matrix can provide resistance to crack propagation and crack opening before being pulled out or stressed to rupture. After extensive studies it is widely accepted that such fiber reinforcement can significantly improve the tensile properties of concrete. Orders of magnitude increases in toughness (energy absorption) over plain concrete are commonly observed [2, 3, 4, and 5].

As out lined by ACI Committee [5] the benefit of fiber reinforced concrete includes improved fatigue strength, wear resistance and durability. Another advantage of fiber reinforcement out lined by Groom [6] is the reduction of the shrinkage and shrinkage cracking of concrete associated with hardening and curing. Reduced shrinkage cracking has been observed even with fiber volume fractions as low as 0.1% of polypropylene fibers.

Fibers for concrete reinforcement generally need to be durable in the cementitious environment, be easily dispersed in concrete mix, have good mechanical properties, and be of appropriate geometric configuration in order to be effective. Many fibers have been used for concrete reinforcement and some of them are widely available for commercial applications. They include steel, glass, natural cellulose, carbon, nylon, and polypropylene, among others. Studies have suggested that polypropylene and nylon, the major fiber types in carpet, are not degraded due to the alkalinity of Portland cement, and are expected to be very durable in concrete [4,5,7].

Groom et al [6] investigated the potential of using nylon fibers to reduce plastic shrinkage cracking in concrete. The nylon fibers were from waste nylon yarns from the carpet tufting operation, cut into a 6.4 mm or a 19.1 mm length. In their laboratory studies, the properties of fresh concrete and the flexural, compressive and splitting tensile strengths of hardened concrete were not significantly affected by the inclusion of nylon fibers at a 0.6 kg/m^3 dosage rate (about 0.13 vol. %). In the plastic shrinkage study, 0.91m x 2.4 m panels with a thickness of 44.5 mm were cast in the field and the total area (length x width) of shrinkage cracks was measured 24 hours later. In comparison with the control panel without fibers, the panel containing 0.6 kg/m3 of 6.4 mm fibers had the same total plastic shrinkage area, the one with 0.9 kg/m^3 of 6.4 mm fibers had a 89% reduction, the one with 0.6 kg/m^3 of 19.1 mm fibers had a 94% reduction, and the one with 0.9 kg/m^3 of 19.1 mm fibers showed no plastic shrinkage crack at the time of measurement.

Naaman et al [8] investigated the effect of polypropylene fibers from carpet waste on the flexural and compressive behavior of concrete and mortar. The fibers were obtained from shredded carpet backing. The fiber length ranged from near zero (powder) to about 25 mm, and about 40% of the fibers were shorter than 5 mm. five fiber volume fractions were used: 0.15, 1.0, 1.3, 2.6, and 3.9%. The matrices included concrete with coarse aggregates, mortar with regular river sand, and mortar with very fine silica sand. Type I Portland cement was used with a water to cement ratio of 0.60 to 0.63. In this paper, the effects of fiber glass and fiber waste contents on compressive strength are studied.

MATERIALS AND METHODS

In order to achieve the stated objectives , this study was carried out in few stage .on the initial stage ,all the material and equipment's needed must be gathered or check for availability. Then the concrete mixes according to the predefined proportions. Concrete samples were tested through concrete tests such as cube test. Finally the results obtained were analyzed to draw out conclusion.

High performance concrete was designed by using BSI curing method. Trail control mixes for 7 and 28 days with using Fiber glass and Fiber waste Additive in concrete with different dosages 0.1%, 0.2%, 0.3%, 0.4% and 0.5 respectively from mixture weight. The results of laboratory experiments were analyzed and discussed to investigate the effect of Fiber glass and Fiber waste additive on workability of fresh concrete and compressive strength of hardened concrete.

Constituent materials of concrete (Materials Used):

Cement*:* The cement used was Ordinary Portland cement (OPC) conforming to British Standards No. 12 of 1996 with a specific gravity of 3.15. Initial and final setting times of the cement were 170 min and 242 min, respectively.

Fine Aggregate*:* The sand used for experimental program was locally procured. The fine aggregates were tested as per British Standard Specification BSI: 882-1997. The specific gravity of sand was found out to be 2.71.

Coarse Aggregate: The natural broken stone (coarse aggregate) used for the study was of 20mm size maximum. It is conforming BSI: 882-1997. It was retrieved from a local quarry .The shape and quality of aggregate was uniform throughout the project work and the specific gravity was found to be 2.6. Table 1 shows the results of tests of impurities, specific gravity and water absorption of coarse and fine aggregates.

Table 1 Properties of aggregates

Experiment name	Fine aggregate	Coarse aggregate
Impurities	% 3	-
Specific gravity	2.71	2.6
Water Absorption	0.764%	0.48%

Water: The used water from Khartoum city water distribution system.

Fiber glass and fiber waste: Fiberglass material is made of very fine fibers of glass. These fibers are finer than human hair, which is in appearance and texture as silk, flexible fiberglass stronger than steel, which is extremely strong and lightweight material. In this project, Fiber glass and fiber waste were chosen, because it is not expensive, inert in high pH Cementious environment and easy to disperse. Fiber glass and fiber waste have good ductility; hence, they can restrain plastic cracks. The fibers increase concrete resistance to fire temperatures. Fibers glass are mainly used to prevent formation of shrinkage cracks or, more precisely, to reduce micro cracking in a new concrete. Fiber glass has density ranging from 5.2 to 7.2 g \ cm ^{3}, which feels heavily fiber weight. Fiber glass has the ability to improve the resistance of concrete in tensile and shear and bending and impact and deflation as it works to reduce the widening cracks and redistribution. The effective influence of the fibers shown to increase the compressive strength and the most important function of the fibers, it increases the value of a calibrated durability of the material is very significant increase. Table 2 shows the fiber glass properties.

Table 2 Properties of Fiber glass

Density(gr/cm^3)	2.54
shape	line
colour	clear
length	5,10,and 15mm
Cohesion in the dry case	9.6 – 6.3
Cohesion in the wet case	6 – 5.4
The percentage gain moisture	%0
Resiliency	Excellent
Combustion	Do not burn but are recited at a temperature of 732
Thermal Conductivity	Weak
Electrical conductivity	Weak

MIX DESIGN METHOD

BSI curing method of mix design was used for mix design for concrete cubes test .concrete specimens with various percentages of fiber and fiber waste were prepared .the details of various mix proportions for different replacement levels of cement by fiber and fiber waste at 7 and 28 days.

The aggregate dry density used was 1600kg/m3 ,and the maximum aggregate size use in all mixes was 20mm .using standard cubes moulds (150*150*150)mm,6 cubes representing each ratio, were casted and tested at age 7 and 28 days.

Components of mix materials:

Concrete Mixes Design: The concrete mix to resist compression design (25N / mm^2) The quantities of materials for all the mixtures as illustrated table3: Mix design: (density of 2375 kg / m ^{3}).

Table 3 shows the amounts of the mixture of design

Mix Materials	Weight(kg/m3)
Cement content	370
Fine aggregate content	660
Coarse aggregate content	1125
Water content	220

Basic mixture of six cubes: the weights of material of the basic components of the mixture and the weight of the fiber glass added to six cubes as illustrated table4

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Table 4 shows the weights of the basic components of the mixture and the weight of the glass fiber added to six cubes

Material		Weight(kg)
Cement content		11.1
Fine aggregate content		19.8
Coarse aggregate content		33.8
Water content		6.6
Fiber glass an d fiber glass content	0.1%	0.0713
	0.2%	0.143
	0.3%	0.214
	0.4%	0.285
	0.5%	0.357

Cube Area = 150×150 = 22.5 ×103 mm^2
Cube Volume = 150×150×150 =3.375 ×106 mm^3.
The result of these experiments have been shown in tables 5 to 9

RESULTS OF EXPERIMENTS OF HARDENED CONCRETE

The results of hardened concrete tests conducted by adding different ratios of the fiber glass, examples of this result for **0.0 %, 0.1%, 0.3% and 0.5% of** fiber glass and fiber waste are shown in tables 5 to 9 and depicted graphically in Figures 1to 6.

Table 5 Results of Compressive Strength Tests of the Control Mix Using (0.0 % of *fiber glass waste)*

Cube No	Age	Area cube	Weigh (gm)		Failure Load (kN)		Strength (N/mm^2)		Average strength (N/mm^2)	
			Fiber waste	Fiber glass	Fiber waste	Fiber glass	Fiber waste	Fiber glass	Fiber waste	Fiber glass
1	7day	22500	8403	8943.1	534.8	826.9	23.7	25.4	24.8	25.3
2			8605	8775.0	554.6	793.1	24.6	23.5		
3			8153	8859.4	587.3	911.3	26.1	27.0		
5	28day		8261	9028.0	769.9	1181.3	34.2	35	34.4	34.0
6			8403	9196.9	771.8	1248.8	34.3	37		
7			8412	7738.0	783	1012.5	34.8	30		

Table 6 Results of Compressive Strength Tests of the Control Mix Using (0.1 % of *fiber glass &fiber waste)*

Cube No	Age	Area cube	Weigh (gm)		Failure Load (kN)		Strength (N/mm^2)		Average strength (N/mm^2)	
			Fiber waste	Fiber glass	Fiber waste	Fiber glass	Fiber waste	Fiber glass	Fiber waste	Fiber glass
1	7day	22500	8303	9281	578.3	843.7	25.7	25.0	25.5	25.3
2			8028	8775	567	877.5	25.2	26.0		
3			8390	9281	573.8	843.7	25.5	25.0		
5	28day		8453	9028	801	1198.1	35.6	35.3	35.1	34.6
6			8185	9028	789.8	1198.1	35.1	35.5		
7			8483	9119	780.8	1113.8	34.7	33.0		

Table 7 Results of Compressive Strength Tests of the Control Mix Using (0.3 % of *fiber glass waste)*

Cube No	Age	Area cube	Weigh (gm)		Failure Load (kN)		Strength (N/mm^2)		Average strength (N/mm^2)	
			Fiber waste	Fiber glass	Fiber waste	Fiber glass	Fiber waste	Fiber glass	Fiber waste	Fiber glass
1	7day	22500	8325	9281.3	643.5	978.8	28.6	29	28.9	29
2			8215	8943.8	654.8	978.8	29.1	29		

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3			8358	9281.0	650.3	978.8	28.9	29		
5	28day		8407	8926.9	895.5	1282.5	39.8	38	40.2	37.5
6			8310	8960.6	902.3	1265.6	40.1	37.5		
7			8424	8781.8	915.8	1248.8	40.7	37		

***Table 8 Results of Compressive Strength Tests of the Control Mix Using (0.5 % of** fiber glass waste)*

Cube No	Age	Area cube	Weigh (gm)		Failure Load (kN)		Strength (N/mm^2)		Average strength (N/mm^2)	
			Fiber waste	Fiber glass	Fiber waste	Fiber glass	Fiber waste	Fiber glass	Fiber waste	Fiber glass
1	7day	22500	8417	8775	573.8	826.9	25.5	24.5	25.8	25.5
2			8314	8781	591.8	977.5	26.3	26		
3			8523	8781	578.3	877.5	25.7	26		
5	28day		8353	9113	810	1198.1	36	35.5	35.2	34.7
6			8423	8910	792	1181.3	35.2	35		
7			8317	8599	771.8	1130.6	34.3	33.5		

***Table 9 Average for Results of Compressive Strength Tests using (% of** fiber glass & fiber waste)*

Fiber& fiber waste Additive (%)	Compressive strength (N/mm^2) With %of fiber waste		Compressive strength (N/mm^2) With % of fiberglass	
	7days	28 days	7days	28 days
Control mix (0.0)	24.8	34.4	25	34
0.1	25.5	35.1	25.5	34.67
0.2	27.2	35.7	26.8	36.1
0.3	28.9	40.2	29	37.5
0.4	26.9	35.9	25.5	34.5
0.5	25.8	35.2	24	32

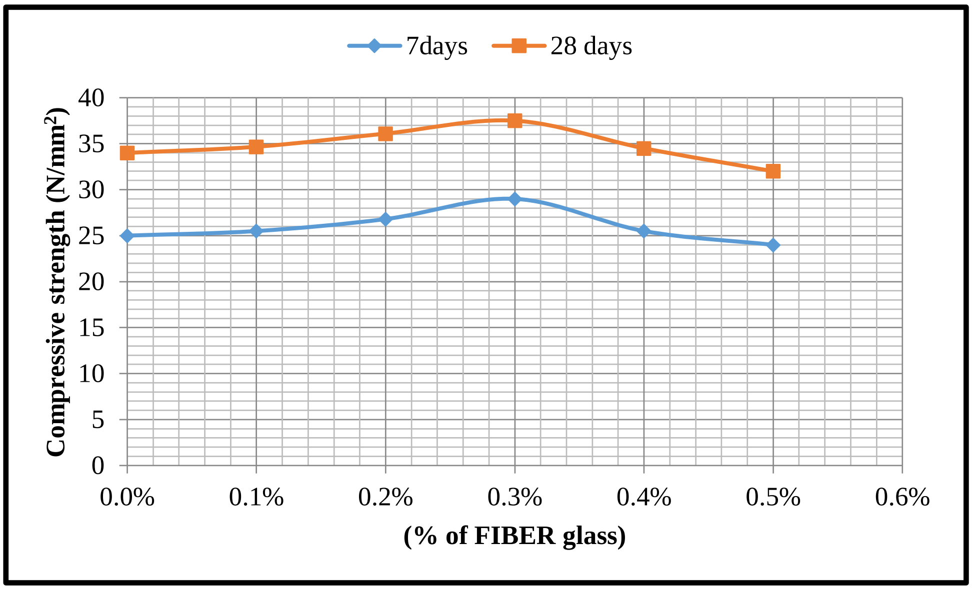

Fig.1 Relation between % of Fiber glass and compressive strength of concrete at ages of 7 and 28 days

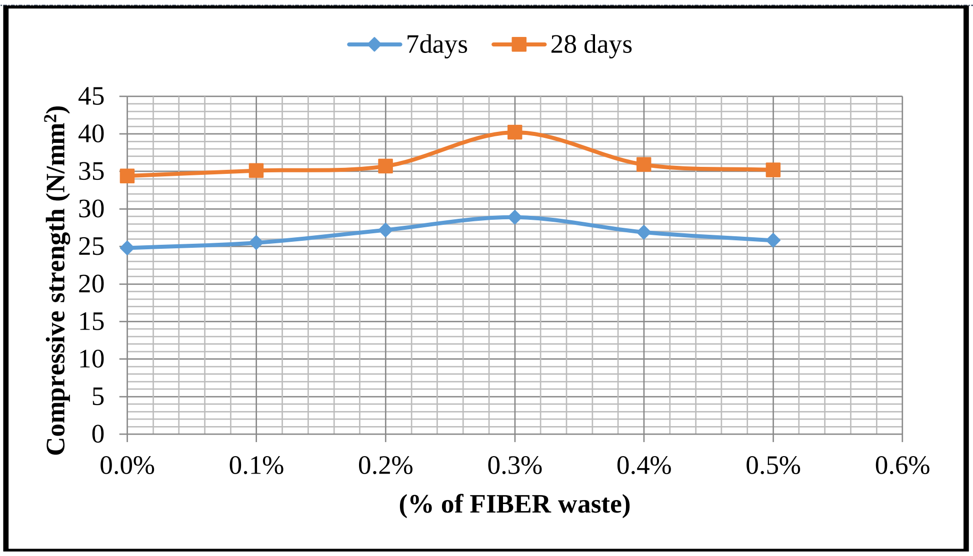

Fig.2 Relation between % of Fiber waste and compressive strength of concrete at ages of 7 and 28 days

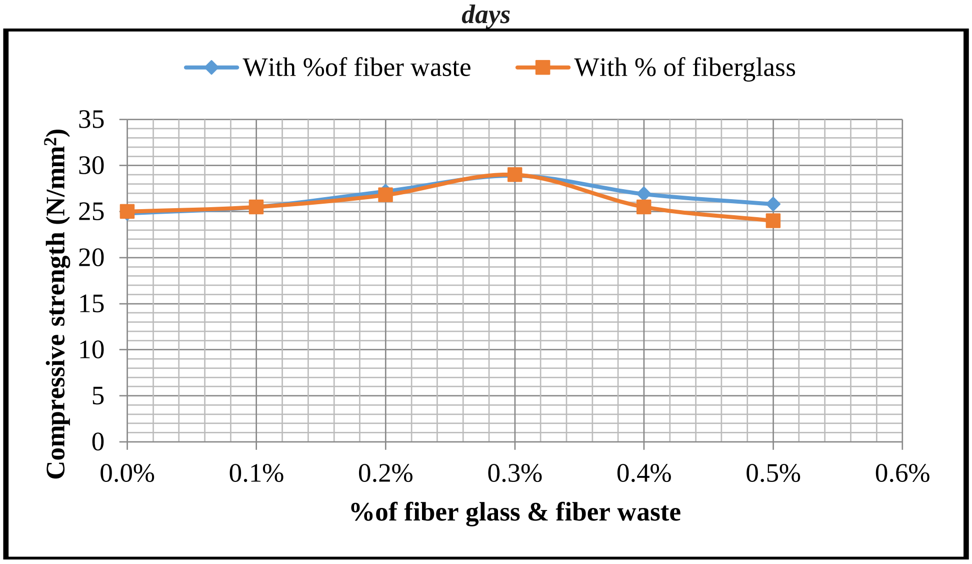

Fig.3 Relation between % of Fiberglass & fiber waste and compressive strength of concrete at ages of 7 days

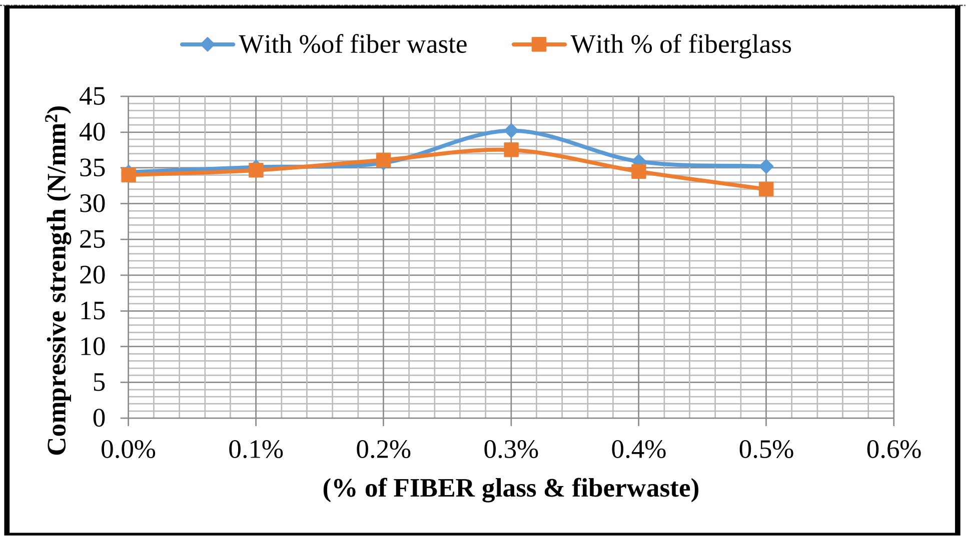

Fig.4 Relation between % of Fiberglass & fiber waste and compressive strength of concrete at ages of 28 days

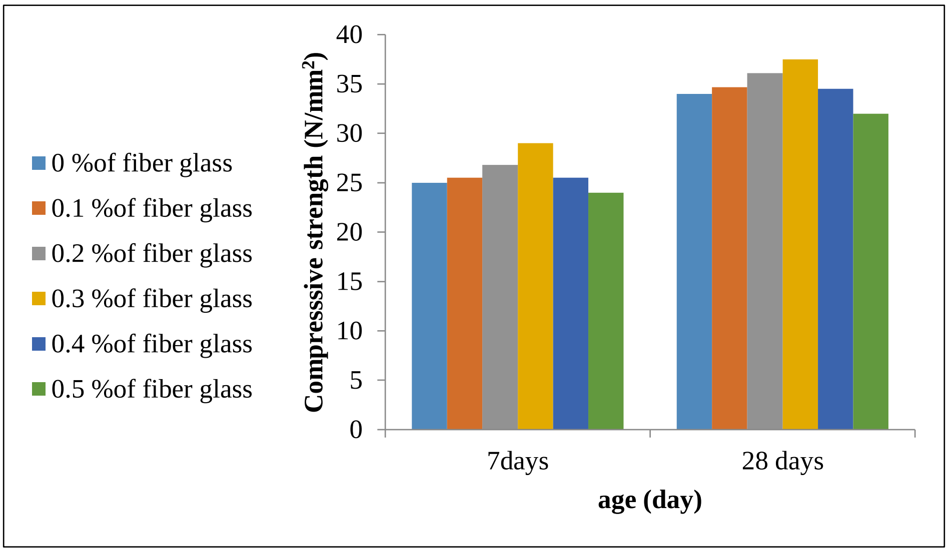

Fig.5 compressive strength of concrete mixes with % of fiber glass at ages of 7 & 28 days

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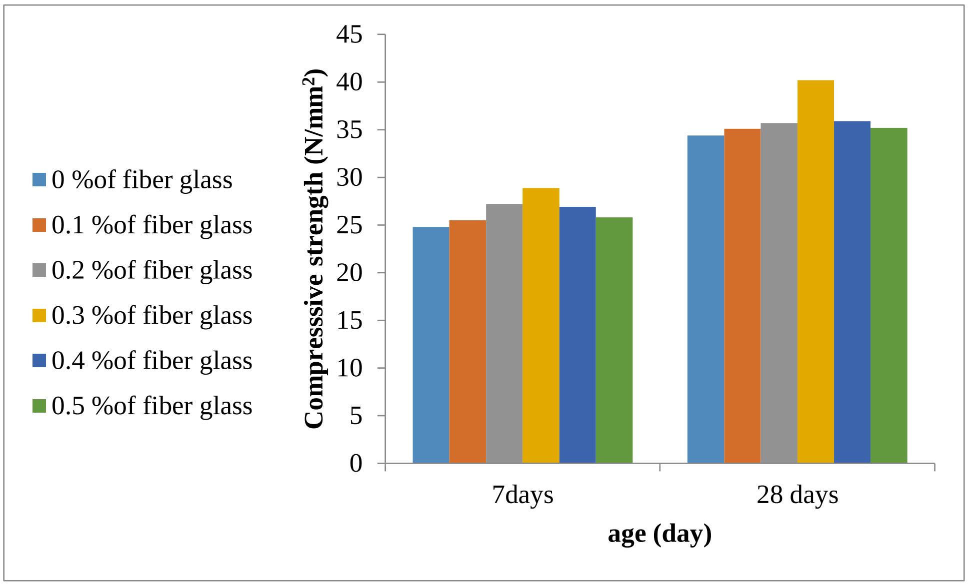

Fig.6 compressive strength of concrete mixes with % of fiber waste at ages of 7 & 28 days

DISCUSSION OF THE RESULTS

The results obtained from the different tests are summarized and discussed as following:

1. Average Compressive strength of concrete in control mix and with additive % of fiber glass and fiber waste increased with increasing of concrete age from 7 to 28 days as shown in Fig 1&2.
2. Average Compressive strength of concrete increased with increasing amounts of fiber and fiber waste to the ratio of 0.3% fiberglass and fiber waste which gave 37.5 MPa and 40.2 MPa at 28 days respectively and also show's beyond these mention proportioned that the compressive strength decreases. After it clear there is an effect on the compressive strength of concrete as shown in table 9 and Fig. 1&2.
3. There is no big difference in values of average compressive strength of concrete at the same ratio of additive of fiber and fiber waste with increasing of concrete ages 7& 28 days as shown in table 9 and Fig. 3&4.
4. The maximum average compressive strength value obtained with additive 0.3% of fiber glass and fiber waste at 7 days are 29Mpa &28.9Mpa and at 28 days are 37.5 Mpa & 40.2 Mpa, respectively as shown in table 9 and Fig. 5&6.

From the previous indicators it has been obtained that the optimum ratio of the fibers can be added to concrete to improve the compressive strength of it is 0.3%, and also show's beyond these mention proportioned that the compressive strength decreases as shown in Fig. 5&6.

CONCLUSIONS

In this study the fiber and fiber waste was used as additive to investigate its effect on fresh and hardened concrete through the measure of workability for fresh concrete and compressive strength for fresh and hardened concrete in 7 & 28 days. Based on the results it can be concluded that:

1. In all cases compressive increase by age of concrete.
2. Maximum 28 days compressive strength of concrete was obtained by addition of 0.3% fiberglass and fiber waste in concrete mixes.
3. In all age the compressive strength of 0.3% fiberglass in concrete mixes is more than 0.4% and 0.5%.
4. For hard concrete the value of average compressive strength concrete increased with increased amounts of fiber and fiber waste up to 0.3% which give high compressive strength 29 MPa and 28.9 MPa for 7days and 37.5 Mpa & 40.2 Mpa for 28 days respectively.
5. Depending on the material cost and results it is advisable to use the fiber waste additive.
6. For fresh concrete the value of slump decreased with increased amounts of fiber and fiber waste.
7. Generally the Fiberglass and fiber waste improved the properties of concrete.

RECOMMENDATIONS

Based on the result of the study performed in this research, the following recommendations can be drawn:

1) 0.3% of fiber and fiber waste additive could be used to obtain concrete mixtures with reasonable strength.
2) Use other type of additives (gum Arabic) with the optimum fiber glass ratio obtained from this research 0.3% to obtained good workability and high compressive strength.

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