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Effect of Steel Fibre from Waste Tyres on the Compressive, Flexural Strength and Workability of Concrete

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ABSTRACT

These studies evaluate the effects of steel fibres from waste tyres to determine the workability, compressive and flexural strength of concrete. Steel fibres were gotten from waste tyres by burning and cut into a length of 60mm, sand was used as fine aggregate while granite was used as coarse aggregate. Dangote cement was used as binder, mixed with portable water. The steel fibres were sectioned into different percentage which are 0%,0.2%,0.4%,0.6%,0.8%,1.0% by total volume of concrete in this study the shape of specimen used for compressive strength was cube by size 100 x100 x100mm while for flexural strength a rectangular beam of size 100 x 100 x 400mm was used. the mix ratio was by weight 1:1.5:3 using grade M20 concrete and 0.4 water/cement ratio a total of 54 samples were casted and cured for both compressive and flexural for 7, 21,28 days before testing. The result showed that there was an increase in the compressive and flexural strength at 7, 21,28days for both 0.2% and 0.4% with a value greater than the control value before three was a gradual decrease in the strength of the SFRC due lot of steel fibres present in the concrete as the percentage increases The result gotten from the slump cone test shows that there was a gradual decrease in the workability of concrete as the percentage of fibre increases

Keywords Effect, Steel Fiber, Waste Tyres Compr, Compressive, Flexural Strength, Workability and Concrete

INTRODUCTION

In recent years, waste pollution has become a major issue in developing third-world countries such as Nigeria. Cities such as Lagos, Kaduna, Aba, Port Harcourt, Onitsha etc. are well-known contributors to the Nigerian air pollution problem, which is contributing to global warming and ozone layer depletion. According to the World Bank, roughly 182 million to 198 million people are exposed to PM2.5 at 38 micrograms per cubic meter of air on an annual basis, which is more than three times the significant global health level considered acceptable by regulators. (Cunningham, 2018). The disposal of waste tyres continues to be a source of worry for environmentalists across the world. Dumping of discarded tyres is a severe environmental issue that mostly affects African cities. (Ndayambaje, 2018).

Automobile tire disposal is a system which is not readily available in the country, every year, hundreds of tons of discarded plastic and rubber items, such as used tires, are abandoned in Nigeria. If such vast volumes of municipal solid trash are not disposed of properly, they can create major environmental contamination to our air, water, and land, affecting our health. Traditionally, scrap tires are retreated and sold to other countries for reuse, or they are processed into crumbs for producing surfaces and chips for use as a solid fuel. Nowadays, by recycling the product, we may help to solve environmental degradation, alleviate energy shortages, and provide enormous economic rewards. Tire recycling, often known as rubber recycling, is the process of reusing vehicle tires that are no longer fit for use on cars owing to wear or irreparable damage (such as punctures). Because of their vast volume, durability, and environmental impact, these tires are among the greatest and most significant types of garbage the poor recycling rates of waste tyres reported in growing and developed countries are caused by the lack of regulatory body for the collection, processing, recycling and disposal of waste tyres (Mpanyana, 2009).

The low rate of recycling in Nigeria has therefore brought engineers together to try to figure out how to modify this tire waste in the casting and making of concrete and structures generally. These waste tires offer an alternate method for acquiring steel fibers for use in concrete at a low or no cost. Meanwhile, it is necessary to establish an appropriate mix percentage of concrete ingredients that allows for the incorporation of such steel fibers. (Awolusi et al, 2019). The average life span of a normal automobile tire is five years; however, this can vary greatly based on a variety of factors (Weissman, et al 2003). More than 90 million motor vehicles (including passenger cars, Lorries, and buses) were produced in 2014, according to the International Organization of Motor Vehicle Manufacturers, and this number is anticipated to rise in the future years. According to the same agency, the total number of automobiles on the road is projected to be over 1.2 billion. Given that each vehicle has at least four tires, it is possible to estimate that more than 4.8 billion tires are in use today as a result of ongoing car manufacturing. It's also possible that over 4 billion old tires are produced each year (Sengul, 2016). Vehicles are becoming more popular. Vehicle production suggests that this figure will continue to rise in the future. Some of these worn tires can be re-grooved or coated and used as spares. The leftover tires, as well as those that have been reused, are referred to as end-of-life tires and are considered junk. The safe disposal of such a large quantity of scrap tires is a significant problem. Landfilling or stockpiling of these tires is no longer permitted in Europe or the United States, since they have become a significant environmental concern. Scrap tires are currently one of the most recycled items in the United States, Europe, and Japan, thanks to tougher restrictions, increased awareness of their economic advantages, and a rise in environmental concern. (Sengul, 2016). The recent influx of migration from rural areas to urban areas in search for economic benefits as increase the rate of construction and development of buildings and other structure (Jhatial et al., 2017),these leads to rapid increase in pollution.

Every year, a large number of discarded tires is produced. Because appropriate tire disposal is becoming more of a problem that must be addressed, several researchers have looked into the usage of recycled tire products in a variety of conventional civil engineering materials. The improper disposal of discarded tires has drawn a lot of attention in recent years due to the environmental damage they pose. It is critical to employ creative recycling procedures in order to properly dispose of these tires. Numerous uses of recycled tires have been established as a result of civil engineering research, including landfills, septic drain fields, subgrade fill, and chemically modified asphalt binder. (LI, et al 2004). of particular interest is the use of waste tires in Portland cement concrete.
The ensuing stockpile would pose serious health and environmental dangers if these discarded tires were not properly disposed of (Papakonstantinou, 2006). The construction industry plays a big and major role in the economic growth, social development (Sohu et al., 2017). Steel fibers are used to hold the tyre in the rim and are constructed of high tensile strength steel wires. The insertion of steel fibers to concrete improves the majority of mechanical qualities (Balaguru and

shah, 1996). Ductility and toughness are said to have improved, although compressive strength has remained same.

MATERIALS AND METHODS

This research was conducted to show the comprehensive experiment explaining the effect of steel fibre on the compressive and flexural strength. These lab tests were carried out to achieve the stated objectives in chapter one. This chapter demonstrates the detailed experimental programme of this investigation includes materials and method that was used, detailed methodology of experimental programme.

Material

1. Cement
2. Fine aggregate(sand)
3. Coarse aggregate (gravel)
4. Steel fibres from tyres

Plate 1: Dangote cement

Plate 2: Waste tyres

Plate 3: Steel fibres

Plate 4: Coarse aggregate

Source of Materials

Dangote cement was used in this study and it was well protected from dampness to avoid lumps. The fine aggregate (sand) was gotten from Omu-aran, kwara state. Coarse aggregate (gravel) was gotten from Omu-aran, kwara state. Waste tyres was gotten from Ilorin kwara state and was burnt in Landmark University Omu-aran kwara state to get the steel fibres from it. The steel fibres were then cut into straight pieces of approximately 60mm.

Mix Proportions

The mix proportion that was used in this study is 1:1.5:3 cement: granite: sand, respectively. Water cement ratio was 0.4, different volume fractions of steel fibres from waste tyres were used (0%, 0.2%,0.4% ,0.6%,0.8%, and 1.0%).

Specimens

The specimen shape used for compressive strength is the cube shape with size of the cube specimen (100 mm x 100mm x 100mmlong) used for each mix while for flexural strength a beam shape with size of (400mm x100mmx 400mm).

Table 3.0 specimen size and shape with volume fraction of steel fiber from waste tyres for compressive strength test

Sample no	Specimen Shape	Size Mm	Steel fibers (%)	Total number of days for curing for the compressive strength test		
				7days	21days	28days
S1	Cube	100 x100x100	0	3	3	3
S2	Cube	100 x100x100	0.2	3	3	3
S3	Cube	100 x100x100	0.4	3	3	3
S4	Cube	100 x100x100	0.6	3	3	3
S5	Cube	100 x100x100	0.8	3	3	3
S6	Cube	100 x100x100	1.0	3	3	3

Table 3.1 specimen size and shape with volume fraction of steel fibers from waste tyres for flexural strength test

Sample no	Specimen Shape	Size mm	Steel fibers (%)	Total number of days for curing for the flexural strength test		
				7days	21days	28days
S1	Beam	100 x100x400	0	3	3	3
S2	Beam	100 x100x400	0.2	3	3	3
S3	Beam	100 x100x400	0.4	3	3	3
S4	Beam	100 x100x400	0.6	3	3	3
S5	Beam	100 x100x400	0.8	3	3	3
S6	Beam	100 x100x400	1.0	3	3	3

MIX PROCEDURE

The method of mixing was achieved by mixing cement, fine aggregate and coarse aggregate and adding water to prepare the concrete, in which steel fibers were added in different percentage as shown table 3.0 and table 3.1above the mixing time was about 5minute. The concrete was thoroughly mixed with the steel fiber to prevent segregation. The steel fiber reinforced concrete was poured into the mould after mixing it successfully and leveled. For individual percentage of steel fibre three sample were casted for compressive and flexural strength at age 7 ,21, and 28 days. The specimen was allowed to dry for about 24 hours and the was removed from the mould and placed in a water basin as a curing method with a controlled temperature of 23-oc_+2-0 according to ASTM 192

Table 3.2 Mix design and proportions

sample	Cement	Sand	Water	Granite	Steel fibers	Water - cement ratio
0%	21.6kg	34.4kg	8.64kg	64.8kg	0kg	0.5
0.2%	21.6kg	34.4kg	8.64kg	64.8kg	0.238kg	0.5
0.4%	21.6kg	34.4kg	8.64kg	64.8kg	0.475kg	0.5
0.6%	21.6kg	34.4kg	8.64kg	64.8kg	0.7128kg	0.5
0.8%	21.6kg	34.4kg	8.64kg	64.8kg	0.9504kg	0.5
1.0%	21.6kg	34.4kg	8.64kg	64.8kg	1.180kg	0.5

Experiments

1. Compressive strength test.
2. Flexural strength test.

3. Slump cone test.

Definition of Compressive Strength

The capacity of a material or structure to carry stresses on its surface without cracking or deflection is known as compressive strength. When a substance is compressed, it shrinks, and when it is stretched, it lengthens.

Compressive Strength Formula

Compressive strength formula for any material is the load applied at the point of failure to the cross-section area of the face on which load was applied.
Compressive Strength = Load / Cross-sectional Area
Procedure: Compressive Strength Test of Concrete Cubes

This concrete is poured into the mould after it has been mixed with the steel fibre and tempered properly to eliminate any voids. Moulds are removed after 24 hours, and test specimens are immersed in water to cure. These specimens' top surfaces should be level and smooth. This is accomplished by applying cement paste to the whole surface of the specimen and smoothing it out evenly. After seven days or 28 days of curing, these specimens are evaluated on a compression testing equipment. Specimens should be loaded progressively at a rate of 140 kg/cm2 per minute until they fail. The compressive strength of concrete is calculated by dividing the load at failure by the area of the specimen.

Concrete Cube Test Apparatus
Compression testing machine
Mixing of Concrete for Cube Test
Mixing by hand
On a watertight, non-absorbent platform, thoroughly blend the cement and fine aggregate until the mixture is uniform in colour. Add the coarse aggregate and stir it in with the cement and fine aggregate until it is evenly distributed throughout the batch. Mix in the water until the concrete is homogenous and the appropriate consistency is achieved. Cubes are being sampled for testing. Clean the mounds and lubricate them.

Fill the moulds with approximately 5 cm thick layers of concrete. Using a tamping rod, compact each layer with at least 35 strokes per layer (steel bar 16mm diameter and 60cm long, bullet-pointed at lower end). With a trowel, level and smooth the top surface. Cube Curing is a term that refers to the process of curing a test specimens are stored in moist air for 24 hours, after which they are marked, removed from the moulds, and kept submerged in clear freshwater until the test is performed.

Test Safety Precautions

Every 7 days, the water for curing should be tested, and the temperature should be 27+-20C.

Calculations of Compressive Strength
Size of the cube
Area of the specimen (calculated from the mean size of the specimen)
Characteristic compressive strength (f ck) at 7 days
Expected maximum load =fck x area x f.s
Range to be selected is ....
Similar calculation should be done for 28-days compressive strength
Maximum load applied =..........tones = ...N
Compressive strength = (Load in N/ Area in mm^{2})=....N/mm^{2}
=...........................N/mm^{2}

Definition of Flexural Strength

Reinforced concrete's flexural strength, also known as the modulus of rupture, is a proxy for this material's tensile strength. The measure of the severe fiber stresses experienced when a part is bent is also known as the modulus of rupture. Tensile stresses can be brought on by factors other than external force, such as warping, steel corrosion, drying shrinkage, and temperature gradient.

Determination of Flexural Strength of the Concrete Experimental Estimation of Flexural Strength using One-point loading test and the Two-point loading test.

Tensile stresses build at the bottom of a simply supported beam a s it is bent, and when they surpass the flexural strength of the be am, fractures begin to appear at the point of greatest bending mo ment, the load causing the crack and the pattern of the crack can be used to calculate the flexural strength of the given concrete member. However, tests like theOnepoint loading test and the Twopoint lo ading test that indirectly evaluate flexural strengthproduce findings that are satisfactory.

Theory/Mechanism

The modulus of rupture, which may be loaded using either symmet rical twopoint loading or one point loading, is a measurement of th e extreme fiber stresses in a part during flexure. Tensile stresses b uild at the bottom of a simply supported beam as it is bent, and when they surpass the flexural strength of the beam, fractures begi n to appear at the point of greatest bending moment, the load causing the crack and the pattern of the crack can be used to calculate the flexural strength of the given concrete member. Procedure for Calculating Flexure Strength of Concrete

1. Unreinforced concrete specimens of size 400 mm x 100 mm x 100 mm are casted using the desired concrete grade and cured properly for 28 days.
2. The test specimens are allowed to rest in water for 2 days at a temperature of 24°C to 30°C before testing.
3. The testing is done immediately after removal of the specimen from the water and while the specimens are **in wet condition.**
4. Reference lines are drawn using chalks at 5 cm from the edges of the specimen on either side to indicate the position of the roller supports
5. The prismatic specimens are supported on rollers of the testing machine. These rollers provide a simply supported condition for the test.
6. The load is gradually applied through two symmetrical rollers on the axis of the beam.
7. Further, load is applied without shock and increased continuously at a rate such that the stress in the extreme fibre increases at approximately **7kg/cm2/minute.**
8. Finally, the load is applied until the specimen fails and the maximum load is noted.

Calculation of Flexural Strength from Lab Test

The Flexural Strength or Modulus of Rupture (fb) is given by

fb = Pl/bd2 (when a > 13.3 cm)
fb = 3Pa/bd2 (when a < 13.3 cm)

Where,
a = the distance between the line of fracture and the nearest support, measured on the centre line of the tensile side of the specimen (cm)
b = width of specimen (cm)
d = failure point depth (cm)
l = supported length (cm)
P = Maximum Load taken by the specimen (kg)
3.7 Slump cone test
The purpose of the slump cone test is to evaluate the consistency or workability of concrete mix that has been created in a laboratory or on a construction site as the work is being done. To ensure that concrete is of a consistent quality throughout the building process, concrete slump tests are performed from batch to batch. The slump test is the simplest, least expensive, and fastest way to determine if concrete is workable.

Factors which Influence the Concrete Slump Test

1. Chemistry, fineness, particle size distribution, moisture content, and temperature of cementitious materials are examples of material attributes. Size, texture, combined grading, aggregate cleanliness, and moisture content dose, kind, combination, interaction, order of addition, and efficacy of chemical admixtures,
2. Concrete's air content
3. Methods and apparatus for batching, mixing, and transporting concrete,
4. Concrete's temperature,
5. Concrete sampling, slump testing methods, and test apparatus condition,
6. Free water content in the concrete and the amount of time since mixing at the time of testing.

Equipment's required for Concrete Slump Test

Mould, such as a slump cone, non-porous base plate, measuring scale, and temping rod, are used for slump tests. The test mold is a frustum of a cone with a height of 30 cm, a bottom diameter of 20 cm, and a top diameter of 10 cm. The tamping rod is 60 cm long, 16 mm in diameter, and rounded on one end.

Procedure for Concrete Slump Cone Test

1. Clean the internal surface of the mould and apply oil.
2. Place the mould on a smooth horizontal non- porous base plate.
3. Fill the mould with the prepared concrete mix in 4 approximately equal layers.
4. Tamp each layer with 25 strokes of the rounded end of the tamping rod in a uniform manner over the cross section of the mould. For the subsequent layers, the tamping should penetrate into the underlying layer.
5. Remove the excess concrete and level the surface with a trowel.
6. Clean away the mortar or water leaked out between the mould and the base plate.
7. Raise the mould from the concrete immediately and slowly in vertical direction.
8. Measure the slump as the difference between the height of the mould and that of height point of the specimen being tested.

Types of Concrete Slump Test Results

- **True Slump** – True slump is the only slump that can be measured in the test. The measurement is taken between the top of the cone and the top of the concrete after the cone has been removed as shown in figure-1.
- **Zero Slump** – Zero slump is the indication of very low water-cement ratio, which results in dry mixes. This type of concrete is generally used for road construction.
- **Collapsed Slump** – This is an indication that the water-cement ratio is too high, i.e., concrete mix is too wet or it is a high workability mix, for which a slump test is not appropriate.
- **Shear Slump** – The shear slump indicates that the result is incomplete, and concrete to be retested.

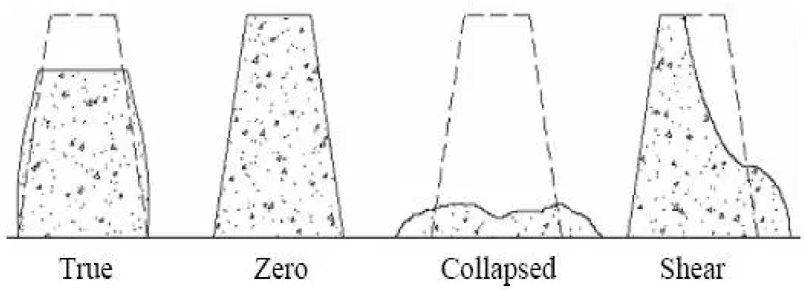

Plate 13: Types of Concrete Slump Test Results

RESULTS AND DISCUSSION

Compressive Strength Test

The compressive strength test was carried out on six (6) samples to determine the compressive strength of steel fibers laced with reinforced concrete.

Reinforced concrete (0% steel fiber)

Table 4.1 compressive strength test of reinforced concrete with 0%, steel fiber for 7 days, 21days, 28days.

S/N	Fcu 1(N/mm)	Fcu 2(N/mm)	Fcu 3(N/mm)	Average Fcu(N/mm)
7days	6.6	7.4	6.5	6.83
21days	8.4	8.5	8.3	8.4
28days	11	10.8	11.2	11

The result of the compressive strength test presented in table 4.1 and figure 4.1 shows the variation of 7 days, 21days, 28days with 0% steel fibers and its shows that there is an increase in compressive strength relatively as the curing day's increases.

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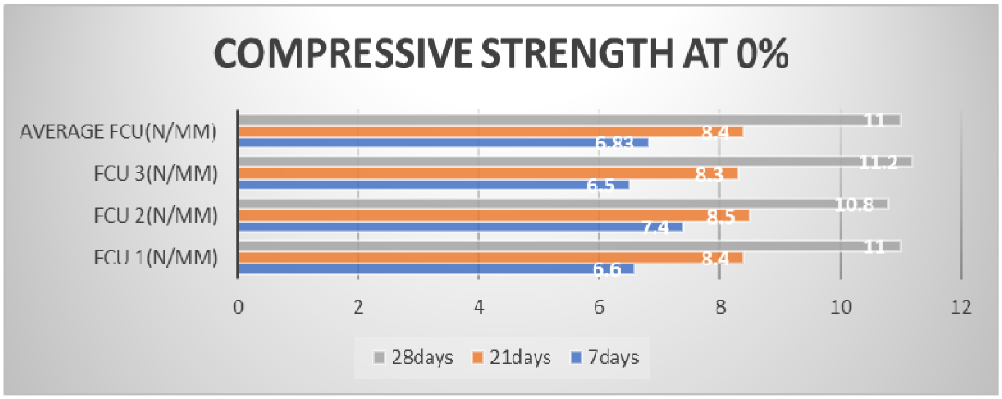

Figure 4.1 variation of compressive strength for steel fibre reinforced concrete (0% steel fibre) at different curing ages

Reinforced concrete (0.2% steel fiber)

Table 4.2 compressive strength test of reinforced concrete with 0.2% steel fiber

S/N	Fcu 1(N/mm)	Fcu 2(N/mm)	Fcu 3(N/mm)	Average Fcu(N/mm)
7days	8.5	8.7	9	8.73
21days	10.7	10.1	10.5	10.43
28days	12.2	12	11.9	12.03

The result of the compressive strength test presented in table 4.2 and figure 4.2 shows the variation of 7 days, 21days, 28days with 0.2% steel fibers and its shows that there is an increase in compressive strength relatively as the curing day's increases.

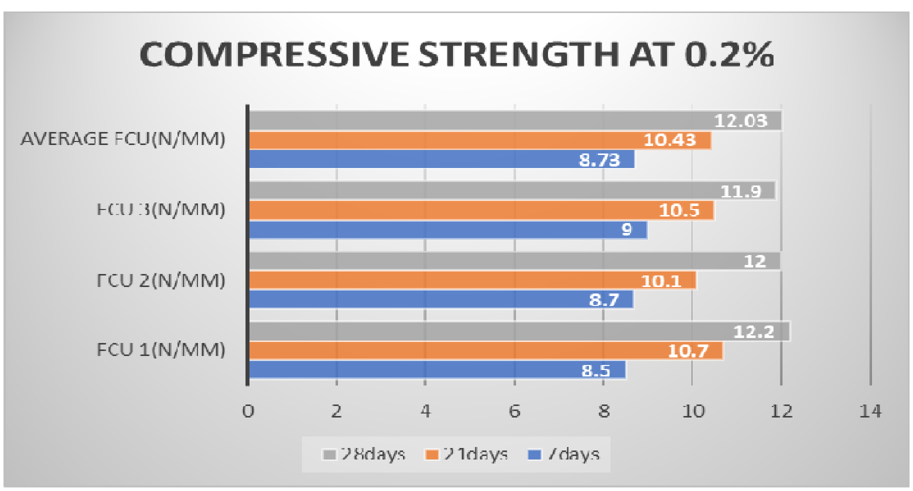

Figure 4.2 variation of compressive strength for steel fibre reinforced concrete (0.2% steel fibre) at different curing ages

Reinforced Concrete (0.4% Steel Fiber)

Table 4.3 compressive strength test of reinforced concrete with 0.4% steel fiber

S/N	Fcu 1(N/mm)	Fcu 2(N/mm)	Fcu 3(N/mm)	Average Fcu(N/mm)
7days	4.4	4.3	4.5	4.4
21days	8.4	8.5	8.6	8.5
28days	9.5	9.4	9.3	9.4

The result of the compressive strength test presented in table 4.3 and figure 4.3 shows the variation of 7 days, 21days, 28days with 0.4% steel fibers and its shows that there is an increase in compressive strength relatively as the curing day's increases.

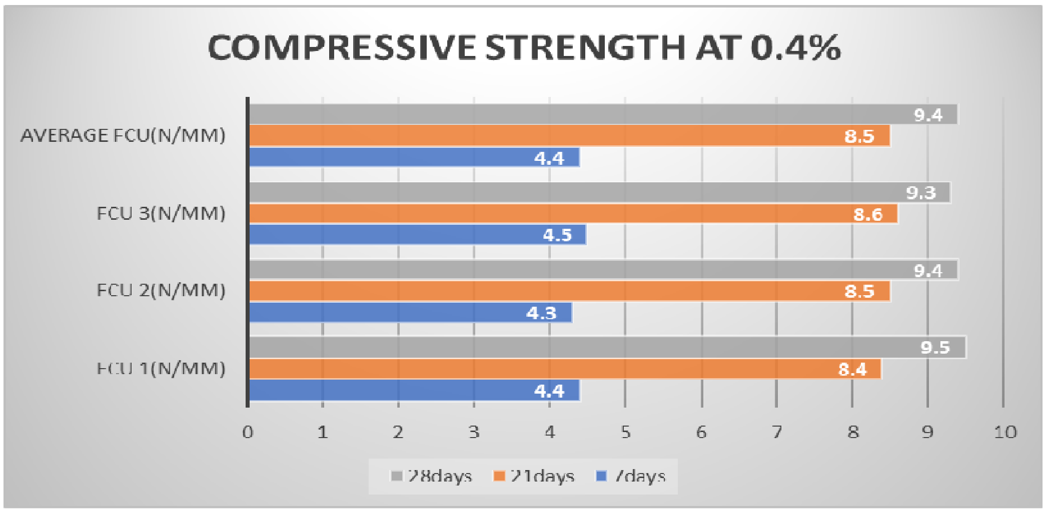

Figure 4.3 variation of compressive strength for steel fibre reinforced concrete (0.4% steel fibre) at different curing ages

Reinforced Concrete (0.6% Steel Fiber)

Table 4.4 compressive strength test of reinforced concrete with 0.6% steel fiber

S/N	Fcu 1(N/mm)	Fcu 2(N/mm)	Fcu 3(N/mm)	Average Fcu(N/mm)
7days	4.5	4	4.1	4.2
21days	5.2	4.9	5	5.03
28days	6.1	6.2	6.2	6.17

The result of the compressive strength test presented in table 4.4 and figure 4.4 shows the variation of 7 days, 21days, 28days with 0.6% steel fibers and its shows that there is an increase in compressive strength relatively as the curing day's increases.

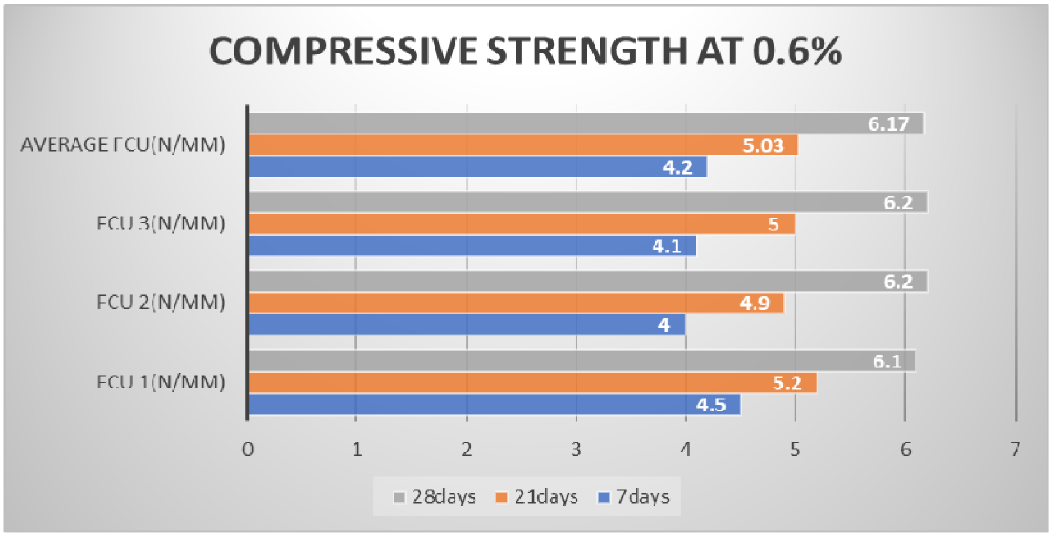

Figure 4.4 variation of compressive strength for steel fibre reinforced concrete (0.6% steel fibre) at different curing ages

Reinforced concrete (0.8% steel fiber)

Table 4.5 compressive strength test of reinforced concrete with 0.8% steel fiber

S/N	Fcu 1(N/mm)	Fcu 2(N/mm)	Fcu 3(N/mm)	Average Fcu(N/mm)
7days	4.2	4.4	3.9	4.17
21days	4.2	4.4	4.1	4.23
28days	4.5	4.2	4.7	4.47

The result of the compressive strength test presented in table 4.5 and figure 4.5 shows the variation of 7 days, 21days, 28days with 0.8% steel fibers and its shows that there is an increase in compressive strength relatively as the curing day's increases.

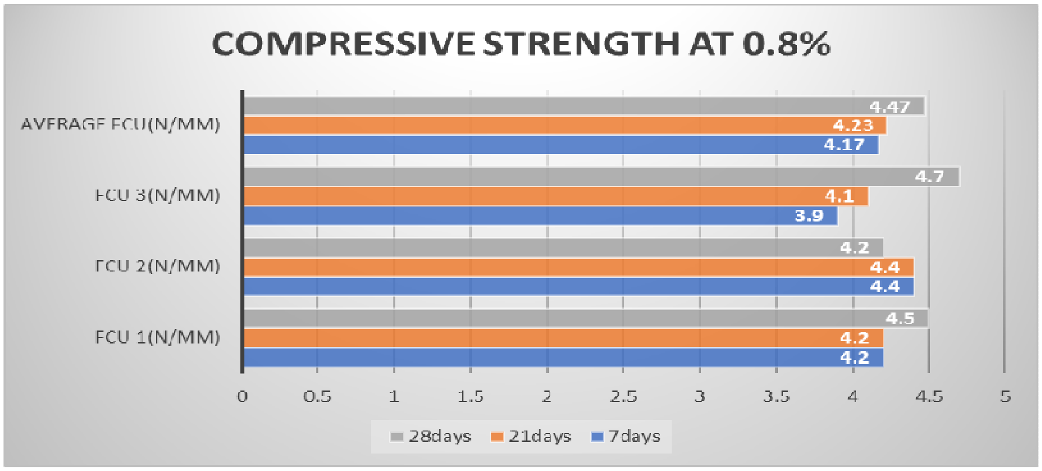

Figure 4.5 variation of compressive strength for steel fibre reinforced concrete (0.8% steel fibre) at different curing ages

Reinforced concrete (1.0% steel fiber)

Table 4.6 compressive strength test of reinforced concrete with 1.0% steel fiber

S/N	Fcu 1(N/mm)	Fcu 2(N/mm)	Fcu 3(N/mm)	Average Fcu(N/mm)
7days	3.9	3.6	3.7	3.73
21days	3.9	4	3.5	3.8
28days	4.9	4.2	4.5	4.53

The result of the compressive strength test presented in table 4.6 and figure 4.6 shows the variation of 7 days, 21days, 28days with 1.0% steel fibers and its shows that there is an increase in compressive strength relatively as the curing day's increases.

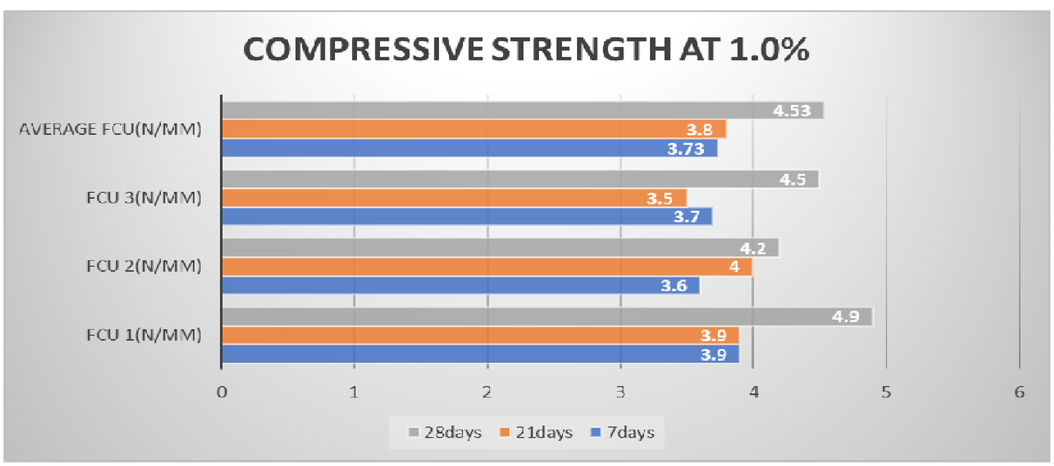

Figure 4.6 variation of compressive strength for steel fibre reinforced concrete (1.0% steel fibre) at different curing ages

Comparison of the Average Compressive Strength Result

Table 4.7 summary of the values for the compressive strength test

Days	0%	0.20%	0.40%	0.60%	0.80%	1.00%
7days	6.83	8.73	4.4	4.2	4.17	3.73
21days	8.4	10.43	8.5	5.03	4.23	3.8
28days	11.0	12.03	9.4	6.17	4.47	4.53

The result of the average compressive strength test presented in table 4.7 and figure 4.7 and 4.8 shows the variation of 7 days, 21days, 28days from 0% to 1.0% steel fibers and its shows that there is an increase in compressive strength relatively as the curing days increases gradual reduction in strength from 0.4% to 1.0% which is less than the control sample 0%.

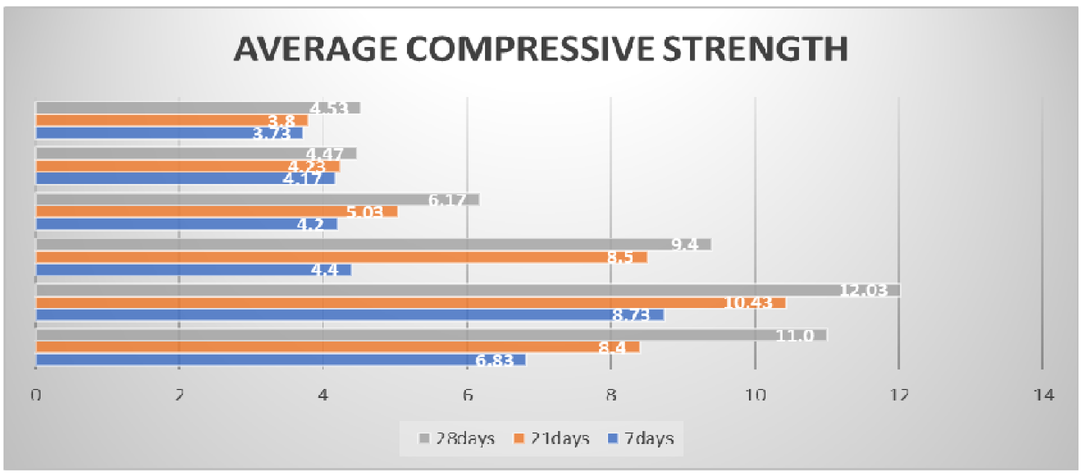

Figure 4.7 Comparison of the Average Compressive Strength Result

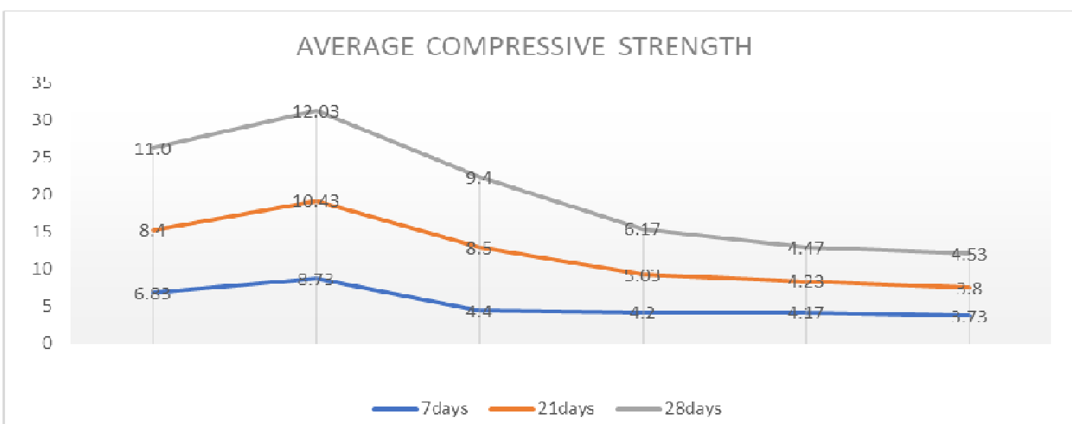

Figure 4.8 Comparison of the average compressive strength result

FLEXURAL STRENGTH TEST

The flexural strength test was carried out on six (6) samples to determine the flexural strength of steel fibers laced with reinforced concrete.

Reinforced concrete (0% steel fiber)

Table 4.8 flexural strength test of reinforced concrete with 0%, steel fiber for 7 days, 21days, 28days.

FLEXURAL STRENGTH TEST AT 0% STEEL FIBER								
Days	P(N)	P(N)	P(N)	AVERAGE P(N)	L(mm)	b(mm)	d(mm)	f_b $(N/mm^2) = 3Pl/(2bd^2)$
7days	22000	30000	30000	27333.3	400	100	100	16.400
21days	32000	30000	34000	32000.0	400	100	100	19.200
28days	37000	28000	35000	33333.3	400	100	100	20.000

The result of the flexural strength test presented in table 4.8 and figure 4.8 shows the variation of 7 days, 21days, 28days with 0% steel fibers and its shows that there is an increase in flexural strength relatively as the curing day's increases.

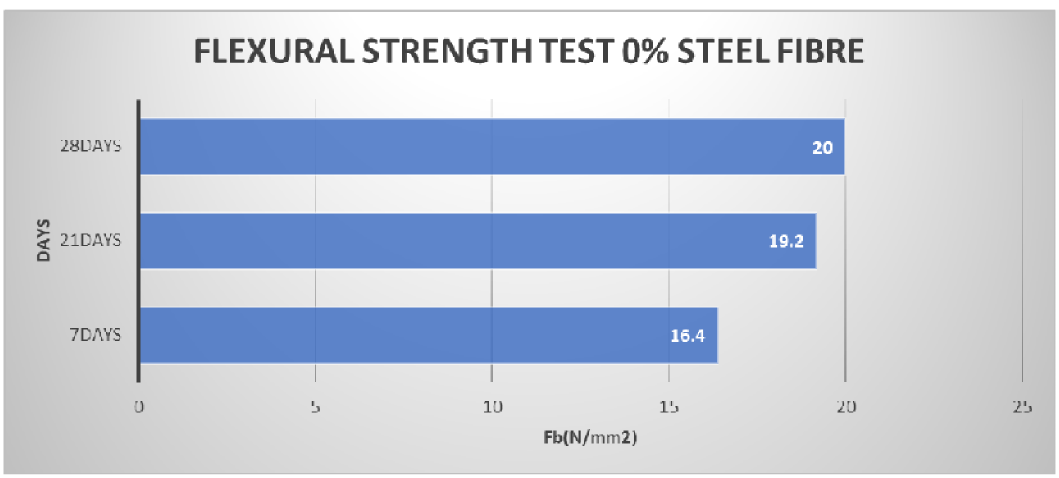

Figure 4.9 variation of flexural strength for steel fibre reinforced concrete (0% steel fibre) at different curing ages

Reinforced Concrete (0.2% Steel Fiber)

Table 4.9 flexural strength test of reinforced concrete with 0.2%, steel fiber for 7days, 21days, 28days.

FLEXURAL STRENGTH TEST AT 0.2% STEEL FIBER								
Days	P(N)	P(N)	P(N)	AVERAGE P(N)	L(mm)	b(mm)	d(mm)	f_b (N/mm²) = 3Pl/(2bd^2)
7days	15000	28000	25000	22666.7	400	100	100	13.600
21days	34000	37000	39000	36666.7	400	100	100	22.000
28days	40000	29000	83000	50666.7	400	100	100	30.400

The result of the flexural strength test presented in table 4.9 and figure 4.9 shows the variation of 7 days, 21days, 28days with 0.2% steel fibers and its shows that there is an increase in flexural strength relatively as the curing day's increases.

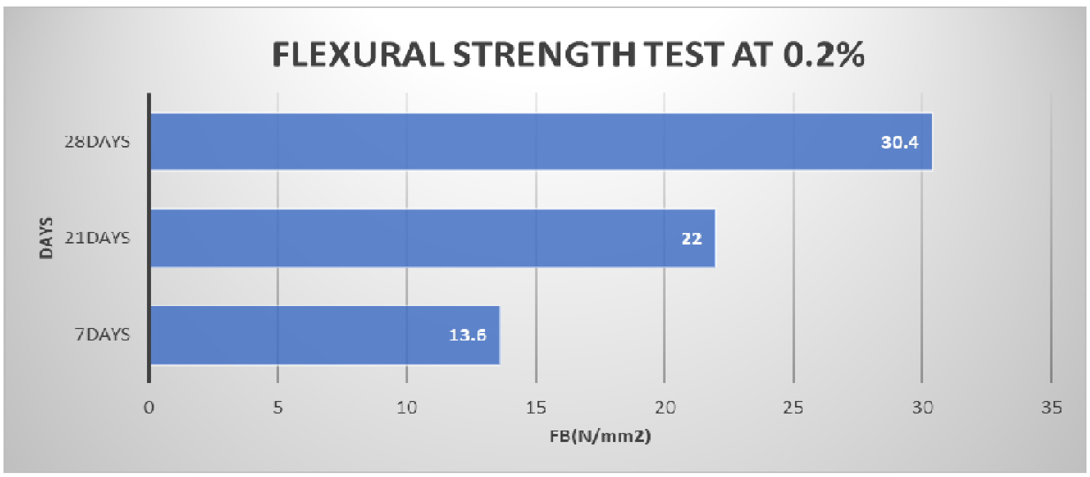

Figure 4.10 variation of flexural strength for steel fibre reinforced concrete (0.2% steel fibre) at different curing ages

Reinforced concrete (0.4% steel fiber)

Table 4.10 flexural strength test of reinforced concrete with 0.4%, steel fiber for 7 days, 21days, 28days.

FLEXURAL STRENGTH TEST AT 0.4% STEEL FIBER								
Days	P(N)	P(N)	P(N)	AVERAGE P(N)	L(mm)	b(mm)	d(mm)	f_b (N/mm²) = 3Pl/(2bd^2)
7days	24000	29000	21000	24666.7	400	100	100	14.800
21days	25000	25000	27000	25666.7	400	100	100	15.400
28days	32000	33000	37000	34000.0	400	100	100	20.400

The result of the flexural strength test presented in table 4.10 and figure 4.10 shows the variation of 7 days, 21days, 28days with 0.4% steel fibers and its shows that there is an increase in flexural strength relatively as the curing day's increases.

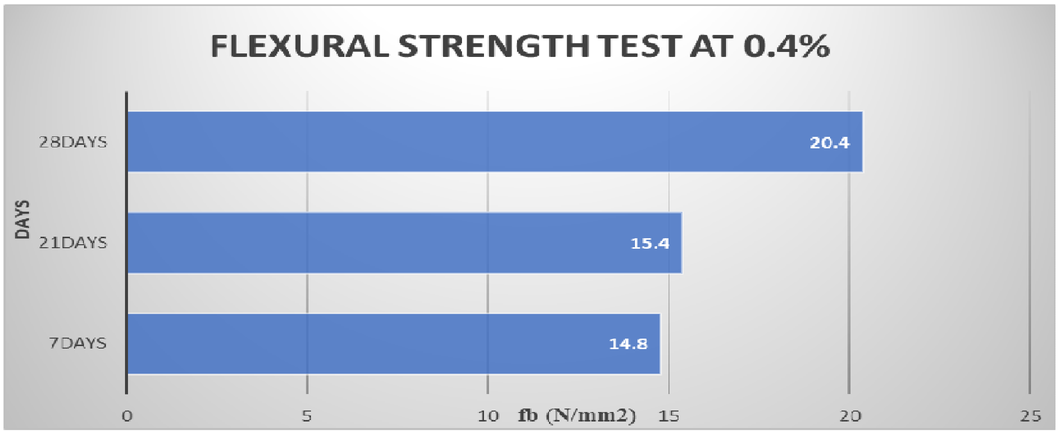

Figure 4.12 variation of flexural strength for steel fibre reinforced concrete (0.4 % steel fibre) at different curing ages

Reinforced Concrete (0.6% Steel Fiber)

Table 4.11 flexural strength test of reinforced concrete with 0.6%, steel fiber for 7 days, 21days, 28days.

FLEXURAL STRENGTH TEST AT 0.6% STEEL FIBER

Days	P(N)	P(N)	P(N)	AVERAGE P(N)	L(mm)	b(mm)	d(mm)	f_b (N/mm^2) = 3Pl/(2bd^2)
7days	18000	24000	24000	22000.0	400	100	100	13.200
21days	25000	25000	27000	25666.7	400	100	100	15.400
28days	29000	27000	27000	27666.7	400	100	100	16.600

The result of the flexural strength test presented in table 4.11 and figure 4.11 shows the variation of 7 days, 21days, 28days with 0.6% steel fibers and its shows that there is an increase in flexural strength relatively as the curing day's increases.

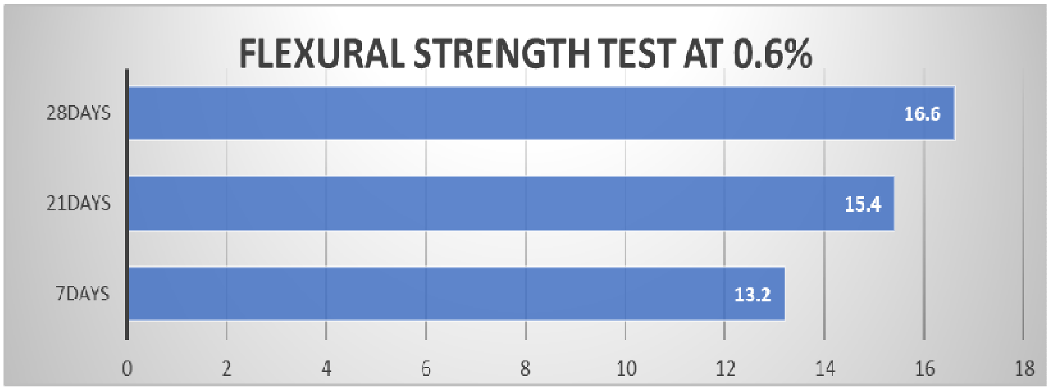

Figure 4.13 variation of flexural strength for steel fibre reinforced concrete (0.6% steel fibre) at different curing age

Reinforced concrete (0.8% steel fiber)

Table 4.12 flexural strength test of reinforced concrete with 0.8%, steel fiber for 7 days, 21days, 28day.

FLEXURAL STRENGTH TEST AT 0.8% STEEL FIBER								
Days	P(N)	P(N)	P(N)	AVERAGE P(N)	L(mm)	b(mm)	d(mm)	f_b (N/mm²) = 3Pl/(2bd^2)
7days	21000	19000	19000	19666.7	400	100	100	11.800
21days	23000	21000	21000	21666.7	400	100	100	13.000
28days	19000	25000	22000	22000.0	400	100	100	13.200

The result of the flexural strength test presented in table 4.12 and figure 4.12 shows the variation of 7 days, 21days, 28days with 0.8% steel fibers and its shows that there is an increase in flexural strength relatively as the curing day's increases.

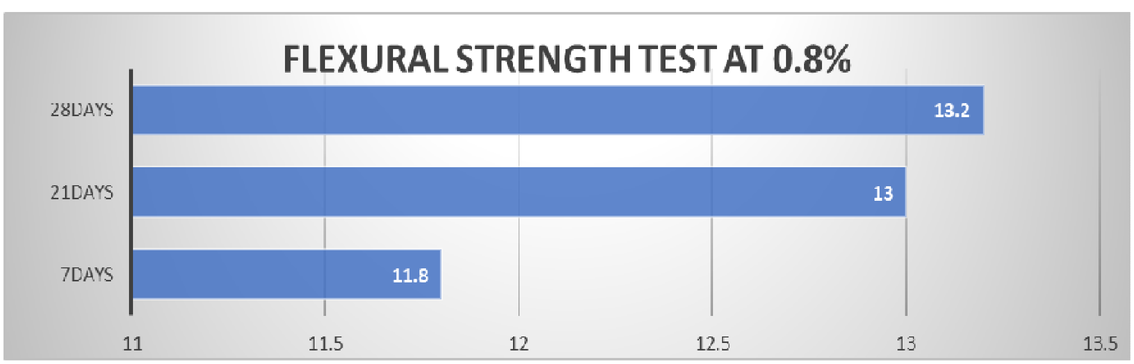

Figure 4.14 variation of flexural strength for steel fibre reinforced concrete (0.8 % steel fibre) at different curing ages

Reinforced Concrete (1.0% Steel Fiber)

Table 4.13 flexural strength test of reinforced concrete with 1.0%, steel fiber for 7 days, 21days, 28day.

FLEXURAL STRENGTH TEST AT 1.0% STEEL FIBER								
Days	P(N)	P(N)	P(N)	AVERAGE P(N)	L(mm)	b(mm)	d(mm)	f_b (N/mm^2) = 3Pl/(2bd^2)
7days	17000	15000	17000	16333.3	400	100	100	9.800
21days	23000	19000	18000	20000.0	400	100	100	12.000
28days	19000	25000	23000	22333.3	400	100	100	13.400

The result of the flexural strength test presented in table 4.13 and figure 4.13 shows the variation of 7 days, 21days, 28days with 1.0% steel fibers and its shows that there is an increase in flexural strength relatively as the curing day's increases.

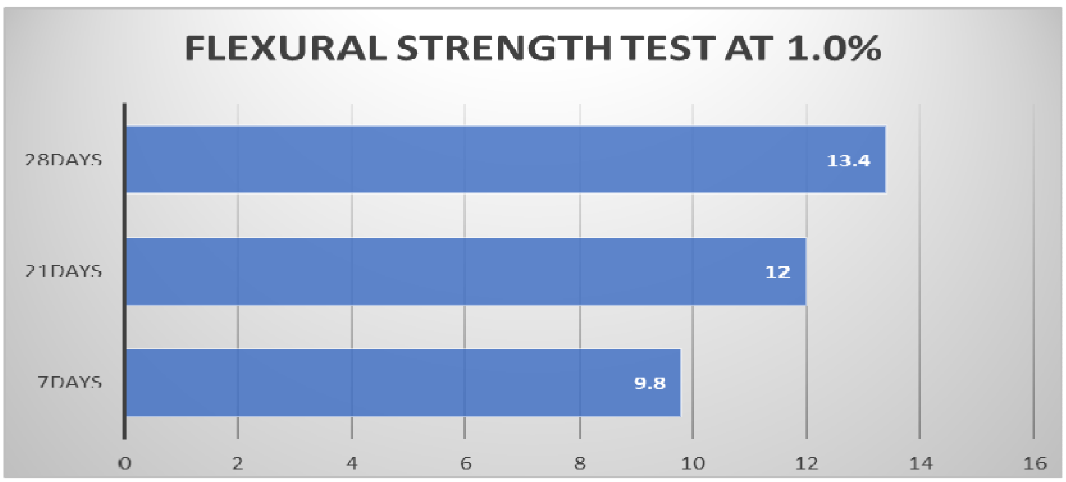

Figure 4.14 variation of flexural strength for steel fibre reinforced concrete (1.0% steel fibre) at different curing ages

Comparison of the average flexural strength result

Table 4.14 **the average flexural strength** of reinforced concrete with 0% to 1.0%, steel fiber for 7 days, 21days, and 28day.

Days	0%	0.20%	0.40%	0.60%	0.80%	1.00%
7days	16.4	13.6	14.8	13.2	11.8	9.8
21days	19.2	22	15.4	15.4	13	12
28days	20	30.4	20.4	16.6	13.2	13.4

The result of the average flexural strength test presented in table 4.14 and figure 4.15 shows the variation of 7 days, 21days, 28days from 0% to 1.0% steel fibers and its shows that there is an increase in compressive strength relatively as the curing days increases gradual reduction in strength from 0.4% to 1.0% which is less than the control sample 0%.

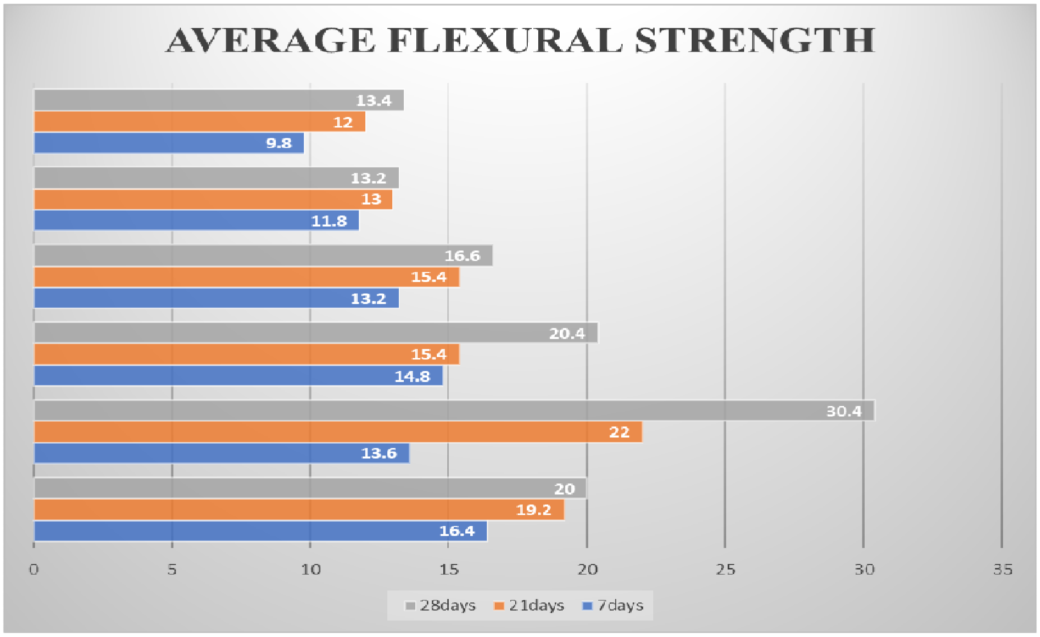

Figure 4.15 **the average flexural strength** of reinforced concrete with 0% to 1.0%, steel fibre for 7 days 21days, 28day

Slump Cone Test

The slump test was conducted to determine the effect of workability of concrete when reinforced with steel fibers. The average slump values are shown in table 4.15 and figure 4.16.

Table 4.15: The workability of SFRC ranging with different percentage of steel fibers

Steel fibers	Slump mm	Slump cone result
0%	55.65	ZERO
0.20%	51.24	TRUE
0.40%	47.75	TRUE
0.60%	43.13	TRUE
0.80%	38.60	TRUE
1.00%	32.95	TRUE

The result of the slump cone test presented in table 4.15 and figure 4.16 shows the variation of 0, 0.2, 0.40, 0.60, 0.80, and 1.0 percentage of steel fibers and its shows that there is a decrease in workability of SFRC relatively as the steel fibers increases.

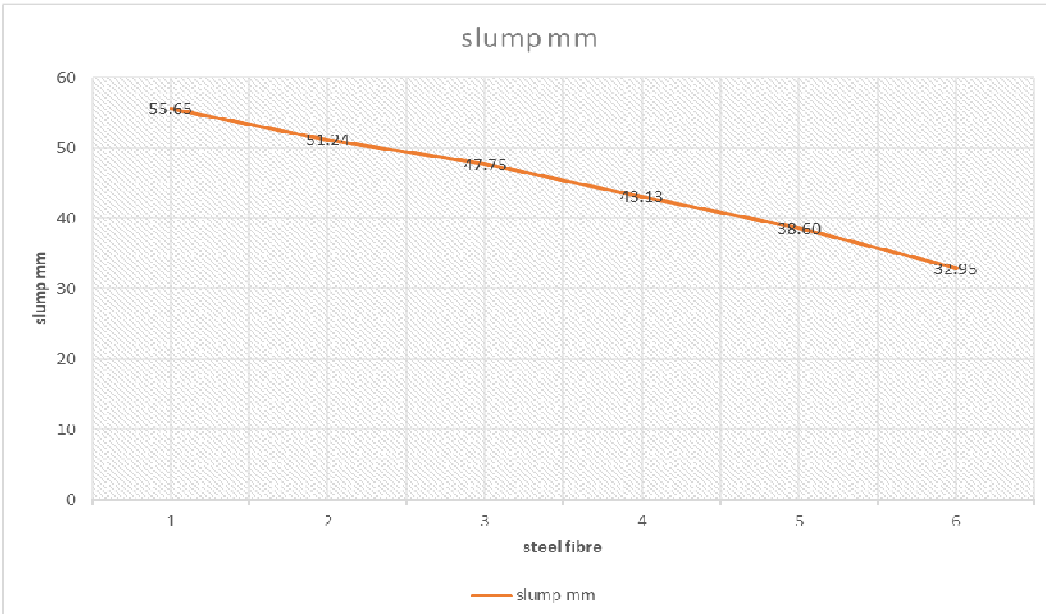

Figure 4.16 variation of the workability of SFRC for different steel fibre percentage.

CONCLUSION

Concrete becomes more ductile when reinforced with steel fibers, which makes it less brittle and increases the mechanical qualities of concrete by allowing it to withstand breaking. The following conclusions are made in light of the findings:

1. Concrete's workability is greatly decreased when steel fibers are employed as reinforcement. Workability was seen to decline as steel fiber volume percentage increased.
2. Concrete's compressive strength was improved by the use of steel fibers as reinforcement. The maximum compressive strength, which was greater than the control sample, was attained by the 0.2 percent and 0.4 percent steel fiber volume fraction reinforcement.
3. Concrete was able to boost its flexural strength thanks to the reinforcement of steel fibers, which led to concrete reinforced with 0.2

percent and 0.4 percent steel fiber by volume fraction achieving the greatest flexural strength that was greater than control sample.

4. The optimal volume percentage of steel fibers was found to be between 0.2% and 0.4%, which produced the highest compressive and flexural strengths with the least amount of workability loss.

5. In addition to knowledge with the steel fiber reinforcement, the concrete has more ductility, which makes it more resistant to cracking and crack spread. Steel fiber reinforcing enables the improvement in flexural strength as a result.

RECOMMENDATION

1. In following studies, the fraction of steel fiber can be raised to examine its impact on workability, compressive strength, and flexural strength of steel fiber reinforced concrete SFRC.P;

2. It should be investigated how to recover steel fibers from used tires without harming the environment by burning them.

3. Other tests might be conducted in later research to identify additional mechanical qualities of steel fiber reinforced concrete SFRC.

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