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Studies on Strength Properties of Fiber Reinforced Concrete.

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ABSTRACT
Slump tests confirmed that the workability of coconut fibre as well as the recron 3s fibre in the mixes goes on decreasing as the fibre content increases in the concrete mix. The slump value decreased from 83mm to 19mm with coconut fibre whereas with recron 3s the decline was observed upto 33mm. Maximum compressive strength to the tune of 35.6MPa was recorded with 0.5% recron 3s whereas maximum value for compressive strength to the extent of 32.1MPa was recorded with 3% coconut fibre. Higher concentrations of coconut fibres recorded negative effect on compressive strength. For tensile strength and flexural strength recron 3s (0.3%) and coconut fibre (3%) recorded beneficial effects in improving the average tensile strength and average flexural strength. However, recron 3s recorded maximum values for average tensile strength and flexural strength to the extent of 3.4MPa & 6.83MPa, respectively compared to 3.14MPa average tensile strength and 6.43MPa average flexural strength achieved with 3% coconut fibre. Higher concentrations in both fibres exhibited detrimental impact. Irrespective of different levels of fibres, 28 days curing recorded maximum test values. Study confirmed beneficial effect of 0.3% recron 3s and 3% coconut fibre as reinforcement for improving compressive, tensile and flexural strength values of concrete.
Key Words: Recron 3s,Coconut fibre, compressive strength, tensile strength ,flexural strength

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I. INTRODUCTION

Cracking in concrete without any fibers will occurs when tensile strength exceeds its limiting value, which results from plastic shrinkage, drying shrinkage and changes in volume of concrete. Pure shear in concrete causes tension on diagonal planes, thus the value of direct tensile strength of concrete is useful in estimating the shear strength of beams with unreinforced webs, etc. Also, the flexural tensile strength of concrete is required for estimation of the moment at first crack required for the computation of deflections and crack widths in flexural members. There are two ways to resist this low tensile strength - by using reinforcement or by pre-stressing. Reinforced concrete is strong in tension and is able to absorb the stresses developing in the concrete so long as a good bond between the concrete and reinforcement or pre-stressing strand is maintained. Development of micro cracks in concrete causes elastic deformation of concrete. By limiting the stresses that the reinforcement has to deal with, the cracking in to concrete can be kept within acceptable limits. The addition of fibers in plain concrete will control the cracking due to shrinkage and also reduce the bleeding of water. For a strong, ductile and durable construction the reinforcement needs to have i)high relative strength, ii) high toleration of tensile strain, iii)good bond to the concrete, irrespective of pH, moisture, and similar factors, iv)thermal compatibility, not causing unacceptable stresses in response to changing temperatures and v) durability in the concrete environment, irrespective of corrosion or sustained stress.

Among natural fibres Coconut fibres are agricultural waste products obtained in the processing of coconut oil and are available in large quantities in the tropical regions of the world, most especially in Africa, Asia and America. Polypropylene fibre has been one of the most successful commercial applications. Recron 3s is the New Generation "Secondary Reinforcement" for Construction Industry. Polypropylene fibres have some unique properties that make them suitable for reinforcement in concrete. The fibres allow density, are chemically inert and non corrosive. Present investigation was thus carried to study the effect of different percentage fibres i.e natural fibre (coconut fibre) and polypropylene fibre (recron 3s) on the compressive, tensile and flexural strength of concrete and to to determine the suitable percentage of coconut fibre and polypropylene (recron 3s) in concrete where the strength of concrete is maximum.

II. MATERIAL AND METHODS

2.1.Materials used

The present study was carried out at concrete lab, Department of Civil Engineering, Sharda University, Greater Noida. Material for the present study comprises of ordinary Portland cement of grade 43 confirming to IS 8112-1989 which consists essentially of compounds of lime (calcium oxide, CaO) mixed with silica (silicon dioxide, SiO_2) and alumina (aluminum oxide, Al_2O_3). The specific gravity of cement was calculated using Specific Gravity Bottle and was found out to be 3.26. Aggregates, which account for 60 to 75 percent of the total volume of concrete, were divided into two distinct categories--fine and coarse. Natural river sand of size 4.75mm and below confirming to zone 3 of IS 383-1970 were used as the fine aggregate. Following tests were being carried out, whereas, **n**atural crushed stone with 20 mm size and 10 mm size were used as coarse aggregate. Portable water was used in concrete to control many fresh and hardened properties of concrete including workability, compressive strength, permeability, water tightness, durability and weathering, drying shrinkage and potential for cracking. The ratio of 0.40 was adopted as the amount of water to the amount of cement used (both by weight).

The coconut fibre used in study was collected from Jagat Farm Greater Noida. The diameter of the fibre ranged between 0.15mm to 0.85mm with the length 6mm to 24mm.

Recron 3s Fibres called as engineered Micro Fibers with a unique “Triangular” Cross-section, used in secondary Reinforcement of Concrete was procured from Kunal Conthem Pvt Ltd Faridabad Haryana.

2.2. Methodology

2.2.1.Mix design

with a target mean strength of 43.25/mm^2 & 35 N/mm^2 Characteristic strength @ 28 days IS-10262-2009 was used for concrete mix design.

2.2.2.Batching and mixing of materials

Recron 3s fibre and coconut fibre was used in various percentages in M35 grade of concrete so as to check the effect of polypropylene and natural fibres on the properties of concrete. Coconut fibre was used in percentages 0%, 1%, 2%, 3%, 4% and 5% and recron 3s fibre used in percentages 0.0%, 0.1%, 0.2%, 0.3%, 0.4%, and 0.5% respectively. These fibre reinforced concrete mixes were checked for compressive strength, tensile strength and flexural strength for a period of 7 days, 14 days and 28 days respectivelyThe batching of materials was done for 7 days, 14 days and 28 days for the compressive strength of concrete. The amount of cement, fine aggregate, coarse aggregate and water remain the same for all the percentages of control mix and fibre reinforced concrete.

2.2.3.Casting of specimen

For compressive strength of concrete cubes were casted and the mixing was done by hand. For each proportion 9 cubes of each of size 100*100*100 mm and 150*150*150mm were casted. Similarly for tensile strength of concrete 9 cylindrical moulds of size 30cm in length and 7.5 cm in diameter were casted. Whereas, for flexural strength of concrete total 33 beams were casted and for tensile strength of concrete cylindrical moulds were casted of size 30cm in length and 7.5 cm in diameter were casted. Cylindrical moulds were cured for 7, 14, 28 days.

Mixing was done by adding coarse-aggregates, followed by 25% of total water. Then fibers and sand was added with 25% of remaining water. After thoroughly mixing of aggregates, cement was added and remaining 50% of water was added. For each mix slump test was conducted to measure workability. After the mixture was prepared it was compacted on a vibration table. Remolding was done after 24 hours of casting. Specimens were cured in curing tank. Water immersion method of curing was adopted

2.2.4.Conduct of tests

2.2.4.1.Compressive strength (kg/cm^2)= W_f / A_p

Where,

W_f = maximum applied load just before load, (kg)

A_P = Plan area of the cube mould, (mm^2)

2.2.4.2.Tensile Strength T = 2P/πld

Where:

T = splitting tensile strength, psi (kPa),

P = maximum applied load indicated by the testing, machine, lbf (kN),

l = length, in. (m), and

d = diameter, in. (m)

2.2.4.3.Flexural strength test: $F_b = pl/bd^2$

Where,

a= distance between the line of fracture and the nearest support

b= width of specimen (cm)

d= failure point depth (cm)

l= supported length (cm)

p= max.load (kg)

III. RESULTS AND DISCUSSION

Perusal of Table -1 depicting basic properties of fine and coarse aggregate revealed

Specific gravity of 2.65 in case of fine aggregate, whereas in coarse aggregate 10mm and 20 mm it was recorded as 2.36 and 2.45,respectively .High specific gravity was associated with maximum water absorption & water content (%) in 20 mm coarse aggregate .

Studies on chemical composition of coconut/coir fibre revealed that lignin, cellulose, pectin and ash are the important constituents (Tabl-2).Test results of the basic properties including length, density, tenacity, breaking elongation, diameter, Rigidity of Modulus, Swelling in water, Moisture and specific gravity of coconut fibre and Diameter (mm), Cut Length (mm), Tensile Strength kg/cm^2, Denier, Melting point, Tenacity (g/d), Elongation (%),Dispersion, and Shape of fiber in Recron 3s Fibres are presented in Table 3& 4.

To test workability of fresh concrete Slump test was performed. The slump test results obtained from the fresh concrete mixes are presented in Figure 1.Results reveal that concrete without fibre recorded maximum slump value (83mm) where as concrete with 0.1% recron 3s recorded the highest slump value (70mm) followed by 0.1% (56mm). Similarly concrete with 1% coconut fibre recorded highest slump value (50mm). Proportionate increase in concentration of fibres showed decline in slump value from 50mm to 19mm with coconut fibre and 70mm to 33mm with recron 3s fibre. The slump test results conclude that the workability of coconut fibre as well as the polypropylene fibre mixes goes on decreasing as the fibre content is increased in the concrete mix. Similar impact of coconut fibre and polypropylene fibre on concrete mix for sump test have also been reported (Nandish et.al. 2015).

By definition, the ultimate compressive strength of a material is that value of uniaxial compressive stress when the material fails completely. The effect of different percentages of recron 3s fibres on compressive strength of concrete revealed that the compressive strength of concrete goes on increasing with an increase in the fibre content of the concrete mix in 7days(21.3MPa), 14days(29.5MPa) and 28 days (32.5MPa). With increase in concentration of recron 3s from 0.1% to 0.5% the average compressive strength got enhanced from 29.4MPa to 35.6MPa showing an increase of 28% (Table-5). Maximum strength to the tune of 40.1MPa was recorded after 28 days in concrete mix blended with 0.5% recron 3s recording an increase of 23.4% over conventional concrete whereas after 7 days the increase in compressive strength was achieved to the tune of 37%. Studies on natural fibre (coconut fibre or coir) confirmed that the natural fibre (coconut fibre or coir) increases the compressive strength of the concrete when 3% fibre was used. Coconut fibre was used in percentages from 0% to 5% by volume of concrete. The compressive strength of concrete increased from 27.76MPa for control mix having 0% fibre content to 32.1MPa for 3% fibre content showing an increase of 15.6%.(Table-6). Increase in fibre concentration (above 4%) recorded decline in average compressive strength by 26.57% (from 32.1MPa to 25.26MPa). Maximum compressive strength was observed with 3% coconut fibre after 28 days (36.4MPa) followed by 14 days (34.7MPa) and 7 days (25.2MPa).

Comparative study on compressive strength revealed significant superiority of 0.5% recron 3s exhibiting highest compressive strength of 40.1 MPa after 28 days of curing with an average strength of 35.6MPa. whereas 3% coconut fibre recorded 36.4 MPa compression strength with an average strength of 32.1MPa after 28 days. Recron 3s was observed to improve compressive strength by 23.38% after 28 days of curing compared to 12% achieved with 3% coconut fibre (Figure 2). Similar results showing impact of recron 3s fibre and coconut fibre for improving compressive strength has also been recorded by several workers (Alida abdullah, 2011, Parveen et. al, 2013; Ealias et. al, 2014; Shreeshail, 2014, Gurrunathan, 2014, Patel et.al, 2015, Desale and Sisode, 2015,Nandish et. al,2015)

Tensile strength which records the resistance of a body to elongation was recorded to be highest with 0.3% recron that improves tensile strength of concrete from 2.65MPa to 3.4MPa showing an increase of 28.3 % over conventional concrete. Increase in concentration in recron 3s (>0.3%) revealed negative impact on average tensile strength and recorded decline by 47%. Study confirmed that concrete mixed with 0.5% recron 3s exhibited lowest average tensile strength (2.31MPa) compared to plain concrete (2.65MPa). 28 days curing recorded maximum tensile strength irrespective of different levels of recron 3s. Maximum tensile strength after 28 days (3.61MPa) was recorded with 0.3% recron 3s showing an increase of 16.4% over plain concrete.(Table-5). For coconut fibre proportional increase in tensile strength from 2.65MPa (conventional concrete mix) to 3.14MPa was achieved with 3% (Table 6). However, higher concentrations of coconut fibre (above 3%) exhibited negative effects on tensile strengths. Highest concentration (5%) recorded least tensile strength (2.4MPa) showing a decline of 9.4% over conventional concrete. For coconut fibre 28 days curing was observed to give desirable results for all the levels under study. Maximum tensile strength (3.56MPa) was achieved after 28 days for concrete mix with 3% of coconut fibre. Comparative study of conventional concrete mix viz-a-viz concrete mix blended with natural and artificial fibres revealed superiority of fibres in improving the tensile strength. For recron 3s there has been constant increase in average tensile strength up to 0.3% to the tune of 16.45% after 28 days where as for coconut fibre desirable effect to the extent of 14.83% was achieved with 3%. For both the fibres 28 days curing recorded best tensile strength (Figure 3). Similar impact of fibres as reinforcement material for improving tensile strength have been reported by (Prasad et. al, 2013, Disale and Sisode, 2015, Nadish et. al, 2015; Parveen et .al, 2013)

Highest Flexural strength, also known as modulus of rupture, bend strength, or fracture strength (6.83MPa) was recorded with 0.3% recron 3s compared to conventional concrete mix showing an average flexural strength of 5.45MPa. Best combination recorded an increase of 25.32% in flexural strength. Highest value of flexural strength (8.25MPa) was recorded with 0.3% after 28 days that arouse from 5.13MPa observed after 7 days.(Table 5). Increase in concentration of recron 3s beyond 0.3% showed decline in flexural strength from 6.83MPa to 5.7MPa.Higher levels of coconut fibre (>3%) recorded decline in average flexural strength from 6.43MPa achieved with 3% coconut reinforcement to 5.7MPa achieved with 5% coconut fibre(Table 6). 28 days curing of concrete mix with 3% coconut fibre recorded highest value for flexural strength (7.48MPa) after 28 days. Best concentration also recorded significant superiority after 7 days and 14 days curing. Flexural strength got increase by 17.9 % with 3% coconut reinforcement. Comparative study of conventional concrete mix with concrete mix reinforced using fibres revealed superiority of 0.3% recron 3s showing an increase of flexural strength by 37.27% compared to 24.4% achieved with 3% coconut fibre after 28 days of curing (Figure 48).) Similar results for flexural strength achieved through fibre reinforcement have also been reported (Prasad et. Al,2013, Disale and Sisode,2015, Nadish et.al.2015,Parveen et.al.2013)

IV. CONCLUSIONS

Incorporation of Recron 3s and coconut fibre concrete enhances the continuity and integrity of concrete thereby increasing long-term tensile strength, which is beneficial to the safety and durability of concrete structures

The addition of a low volume fraction of recron 3s fibres inhibits microcracking, bleeding and increase cement hydration in fresh concrete, thereby reducing surface permeability and reduction in formation and growth of micro cracks in concrete. Hence, it offers low permeability which in turn contributes to better durability and corrosion resistanc

Usage of recron 3s fibers will reduce the cost of maintenance by reducing the micro cracks and permeability and hence the durability will increase. It is found that use of recron 3s fibre reduces the segregation

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Table1: Basic properties of fine and coarse aggregate

Properties	Fine aggregate	Coarse aggregate (10mm)	Coarse aggregate (20mm)
Specific gravity	2.65	2.36	2.45
Free surface moisture	-	0.028	1.976
Water absorption(%)	1.50	0.65	1%
Water content(%)	-	1.38	1.4%

Table 2:Chemical Composition of Coconut / Coir Fiber:

S No	Chemical Composition	Content(%)
1	Lignin	45.84
2	Cellulose	43.44
3	Hemi-Cellulose	00.25
4	Pectin's and related Compound	0.3.00
5	Water soluble	05.25
6	Ash…	02.22

Table 3:Physical Properties of Coconut / Coir Fiber

S No	Property	Value
1	Length (inches)	6 to 8
2	Density (g/cc)	1.40
3	Tenacity (g/Tex)	10.0
4	Breaking elongation (%)	30
5	Diameter in mm	0.1 to 1.5
6	Rigidity of Modulus (dyne/cm2)	1.8924
7	Swelling in water (diameter) %	5
8	Moisture at 65% RH (%)	10.5
9	Specific gravity	0.87

Table 4: Basic properties of recron 3s fibre.

S.NO	Property	Value
1.	Diameter (mm)	0.4
2.	Cut Length (mm)	6mm or 12
3.	Tensile Strength kg/cm^2	4000-6000
4.	Denier	11.4-12.6
5.	Melting point	>250oc
6.	Tenacity (g/d)	Min. 3.5
7.	Elongation (%)	50-70
8.	Dispersion	3-4
9.	Shape of fiber	Special triangle shape

Table 5:-Effect of different levels of Recron 3s on Average Compressive, tensile and flexural **Strength (MPa) 28 days of curing.**

S No	Percentage Of Recron 3s (%)	Average Compressive Strength (MPa)	Average tensile strength (MPa)	Average flexural strength (MPa)
1	0	27.8	2.65	5.45
2	0.1	29.4	2.72	5.9
3	0.2	30.8	3.2	6.33
4	0.3	31.9	3.4	6.83
5	0.4	33.9	2.62	6.08
6	0.5	35.6	2.31	5.7

Table 6:-Effect of different levels of Coconut fibre on Average Compressive, tensile and flexural Strength (MPa) 28 days of curing

S No	Percentage Of coconut fibre (%)	Average Compressive Strength (MPa)	Average tensile strength (MPa)	Average flexural strength (MPa)
1	0	27.76	2.65	5.45
2	1	27.97	2.8	5.63
3	2	28.53	3.0	6.03
4	3	32.1	3.14	6.43
5	4	29.3	2.93	6.18
6	5	25.36	2.4	5.7

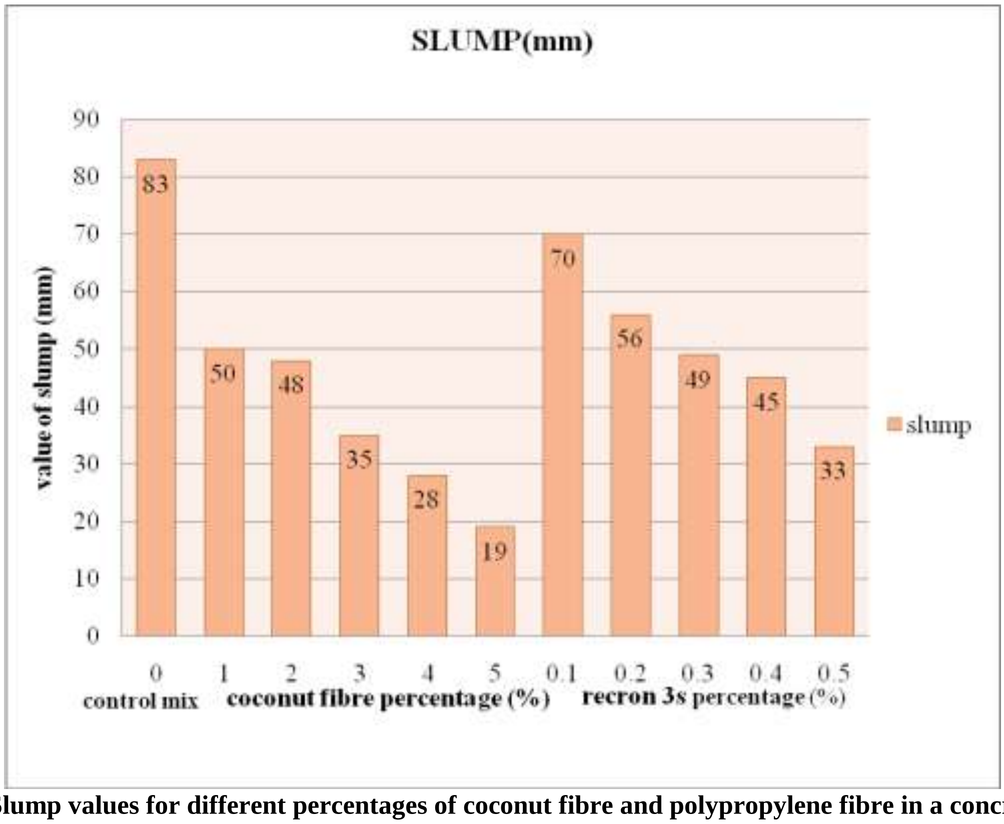

Fig 1 : Slump values for different percentages of coconut fibre and polypropylene fibre in a concrete mix.

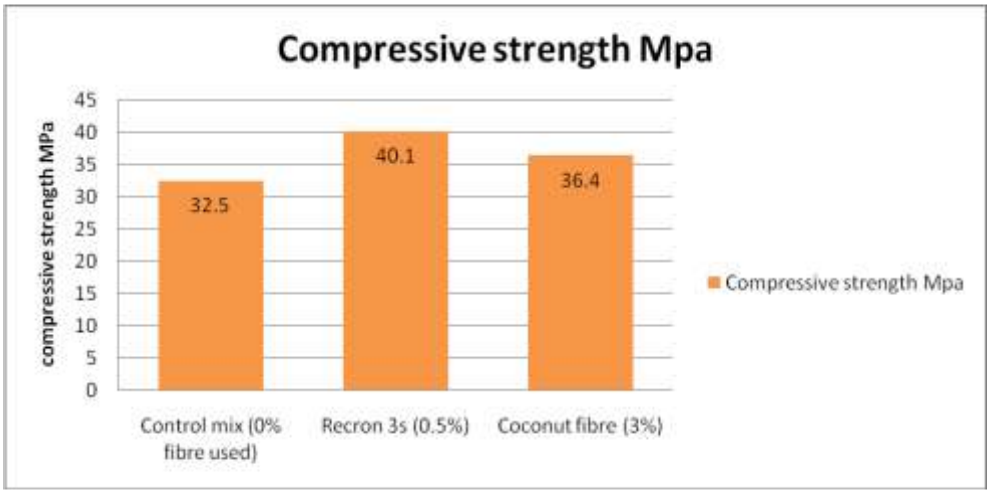

Figure 2:Effect of fibre reinforcement in concrete for improving compressive strength after 28 days of curing

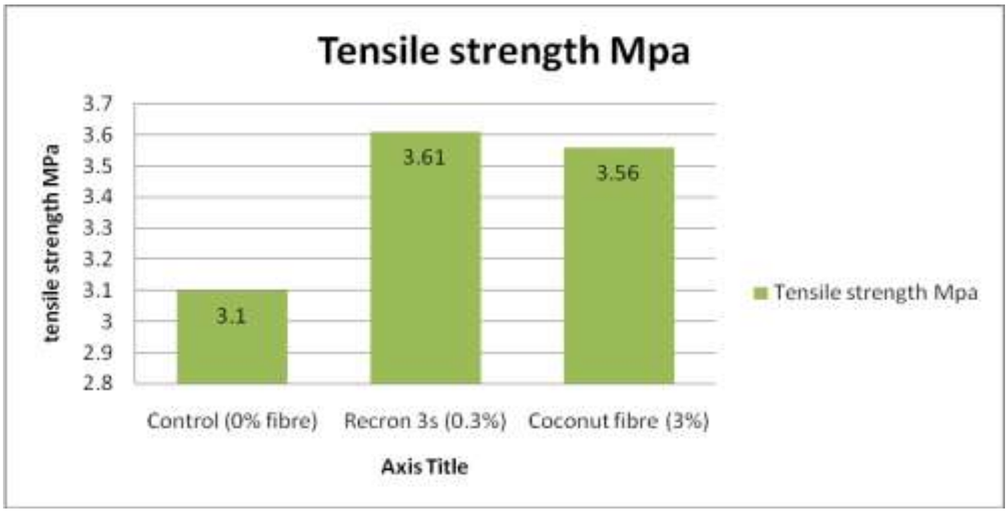

Figure 3: Effect of fibre reinforcement in concrete for improving tensile strength after 28 days of curing

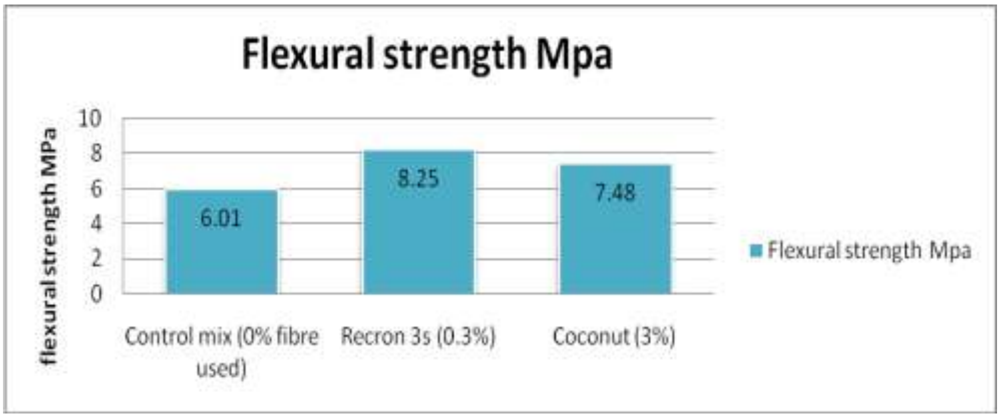

Figure 4: Effect of fibre reinforcement in concrete for improving flexural strength after 28 days of curing

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