Experimental Study On Strength And Durability Of M25 & M30 Grade Of Nylon Fiber Concrete With Acid Curing

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Abstract: Concrete is a composite material composed of fine and coarse aggregate bonded together with a fluid cement that hardens over time. Generally concrete is strong in compression but week in tension. The main objective of this study is to investigate and compare the characteristic strengths of M25 grade nylon fiber concrete with M25 grade plain concrete t characteristic strengths of M25 grade nylon fiber concrete with M25 grade plain concrete and also compare the durability of above two types of concrete. By the use of nylon fiber, nylon is a generic designation for a family of synthetic polymers. The use of nylon fiber in concrete gives good characteristic strength of concrete. In this study, experimental investigation is divided into two stages. In the 1st stage, collect the material and study the various properties of material. Based on the properties of materials, prepare the mix design for M25 & M30 grade of concrete according to the code book IS 10262:2019 and cast the cubes of size (150*150*150mm),beams (500*100*100 mm)& cylinders (300*150mm) these specimens cured with water and acid (HCL) for a period of 7, 14, 28, days. In the 2nd stage, add nylon fiber with various percentages of 0.15%, 0.30%, 0.45%, 0.60%, mix to the M25 & M30 grade of concrete and cast the cubes of size (150*150*150mm), beams (500*100*100mm) & cylinders (300*150mm) ,these specimens cure in the portable water and acid (HCL) for a period of 7, 14, 28 days. Finally compare the strengths of compressive, split tensile and flexural strength of nylon fiber concrete of water curing and acid curing after 28 days.
Keywords: *Concrete, Nylon Fiber, Compressive strength, Flexural Strength, split tensile*

INTRODUCTION: Concrete is when combined with water, bonds the coarse and fine particles together. The concrete's inherent properties have made it so popular and essential. As a result, concrete applications have undergone a revolution, and there are many possibilities for creative new uses, designs, and building methods. It is a very competitive building material due to its high degree of adaptability and relative affordability in meeting a variety of purposes.

Corrosion of the steel by the salt is a common problem for civil constructions made of steel-reinforced concrete, which leads to the collapse of those structures. To ensure that those civil constructions last their intended lives, ongoing maintenance and repair are required. To enhance the structural qualities of concrete, particularly tensile and flexural strength by the addition Of nylon fiber.. The degree of mechanical property improvement achieved with NFRC over plain concrete depends on a number of factors, including all the form, size, volume, percentage, and distribution of fibres.

Resistance against cracks and failures are the factors taken into account when designing residential, public & industrial structures. the service record of concrete in resistance of compressive forces. But in the tensile zone reinforcement resist the tensile forces against bending. Surface cracks are developed in the early stages of concrete doesn't resist by the reinforcement. Fibers are the best admixtures to resist the tension failures.

Concrete is the most common construction material due to its durability and cost ratio.. However, when exposed to extreme environmental conditions, degradation can lead to a severe los in durability. Highly corrosive concrete structural degradation is a highly serious issue with significant economic implication. Cement used for concrete mix is a mixture of complex Compounds. When cement is mixed with water, reaction with the water causes the cement to set and harden.

FRESH CONCRETE

Fresh is define as the stage of concrete in which concrete can be molded in its plastic state.

Properties of Fresh Plain Concrete

Following are the properties of fresh concrete

1. Setting of Concrete
2. Workability of Concrete
3. Bleeding of Concrete
4. Segregation in Concrete
5. Hydration in Concrete
6. Air Entrainment

ACIDIC EFFECT ON CONCRETE

Concrete is susceptible to acid attack because of its alkaline nature, The compounds of the cement paste break down during contact with acids. Out of which the most pronounced is the dissolution of Calcium hydroxide which occurs as shown in below reaction:-

$2HX + Ca(OH)_2 \text{ -}\geq Cax_2 + 2H2O$

X is –ve ion of the Acid)

The decomposition of the concrete depends on the acid content in the cement and the solubility of the acid calcium salts (CaX2) paste. In the voids, insoluble calcium salts may precipitate and impede the attack. Acids like H2SO4, nitric acid, hydrochloric acid, and acetic acid are extremely intrusive due to the ease with which their calcium ions dissolve and are expelled from the body. Concrete is severely damaged by sulfuric acid because it resists both acid and sulphate attacks.. Na2CO3 is negligible compared to HCL (HCl has a mild attack).

HYDROCHLORIC ACID ATTACK (HCL)

HCL is a typical natural chemical component that can harm concrete in seaside and industrial situations. Hydrochloric acid has very strong effects on concrete. Loss of strength is brought on by a change in mineralogy brought on by leaching processes, and HCL corrosion damage makes it unsafe to utilise concrete structures. especially when bending or tensile loads are placed on the structure. The flexural strength loss caused by HCL corrosion is greater in high strength concrete than in regular strength concrete, indicating that sensitivity to HCL corrosion rises with concentration.

Attacked by Hydrochloric Acid (HCL) damages the concrete through dissolution process, soluble salts are formed during this process and the concrete will be percolate because of them. The process increases the pH of acidic solution. Then, hydrolysis can be resumed and finally Si, Al and Fe gels will be produced. During the test, it was observed that the color of the external surface of the sample is yellow whereas the color of their inner surface was brown. This is due to differences in the amount of Fe (OH)3 ; the researchers have considered that the reaction of the hydrochloric acid attack occurs on the layers that separate areas are made up [6-10]. Results of the destruction of concrete.

NYLON FIBER REINFORCED CONCRETE

The tensile strength, crack resistance, durability of plain concrete are all quite low. concrete naturally contains internal cracks and these micro cracks spreads ,the concrete becomes brittle and fractures. This results inadequate tensile strength.In plain concrete structural can appear even before the concrete loaded, often as a results of drying shrinkage or other volume related factors.

A crack arrestor and improve static and dynamic properties if concrete would results from the addition of small , closely spaced ,uniformly dispersed fiber to concrete .this is call fiber reinforced concrete.

Properties of Nylon Fiber Concrete

1. High mechanical stability
2. Excellent durability
3. High heat resistance

4. High abrasion resistance
5. Corrosion resistance

NECESSITY OF THE WORK:

Corrosion of the steel by the salt is a common problem for civil constructions made of steel-reinforced concrete, which leads to the collapse of those structures. To ensure that those civil constructions last their intended lives, ongoing maintenance and repair are required. There are many strategies to reduce the likelihood that steel-reinforced concrete constructions may fail. Fiber polymer composites are adherent-bonded into the structure as part of the bespoke method. This aids in boosting the composite's toughness and tensile strength as well as its cracking resistance and deformation properties.

OBJECTIVES OF THE WORK:

This study primary objective is to investigate the strength of concrete reinforced with nylon fiber and cured with water and acid(HCL). The following are the associated goals of the current study

1) The comparative study of normal curing and Acid curing properties of M25 grade concrete using Nylon fiber. The test specimens were tested for the values compressive strength, tensile strength, and flexural strength tests after curing for 7, 14, and 28 days.
2) To analyze workability of concrete.
3) To analyze the strength and structural properties under normal water and HCL acid.
4) To enhance the capacity of concrete resistance against cracking.

ENVIRONMENTAL BENEFITS OF NYLON FIBER:

Fiber-reinforced polymer (FRP) reinforced structures were compared to steel reinforced structures in terms of their environmental load. The use of fibre can improve the concrete mix and pavement structure during construction, minimise the requirement for steel corrosion maintenance, and create new recycling options during disposal. All of these factors were looked at in the current study, This is mostly due to the fact that fiber-reinforced pavement requires less maintenance, allows for a reduction in cement content and concrete cover over reinforcement, and produces less environmental burden on its own.

LITERATURE REVIEW:

a. R. Mutsuddy and S. Samrose1 investigate in 2019 ,“DURABILITY OF NYLON FIBER REINFORCEMENT CONCRETE EXAMINATION” Construction materials that are frequently used include cement concrete that has steel reinforcement. However, when exposed to a harmful climate, these kinds of reinforced concrete constructions start to deteriorate. The service life of a structure is frequently shortened by these types of deterioration.. One method for enhancing durability is the use of more cementitious material. The majority of Bangladeshi cement manufacturers currently produce Portland Composite Cement (PCC), which contains various additional cementitious materials (fly ash, slag etc.). However, studies have shown that adding tiny fibre reinforcement to concrete increases its resilience (i.e. steel, polypropylene, jute etc.).Nylon is a widely accessible non-reactive material that can be utilised as fibre reinforcement in cement concrete. This study compares how OPC and PCC perform in terms of improved durability, which in turn affects the service life of a structure, as well as the use of nylon fibre. With additional cementitious ingredients, PCC reinforced with nylon performs better. In order to estimate the ideal nylon fibre composition, electrical induction from the Rapid Chloride Penetration Test (RCPT) and chloride migration coefficient from the Rapid Migration Test (RMT) are also calculated.

b.”Experimental examination on strength properties of nylon fibre reinforced concrete payments" was studied by Alex Tharun P J, Aneesha S Pushpaan, and Anjitha U G. Many studies are currently being done to incorporate fibre in concretes in order to enhance the qualities of concretes and lessen the downsides of standard concrete. Concrete that has been reinforced with fibrous materials has a higher degree of structural integrity. It prevents cracking

brought on by plastic and drying shrinkage, lowers concrete permeability, and lessens water bleed. Certain fibre kinds give concrete stronger, more impact-resistant qualities. The fibre under study is nylon. The strength investigation is done on concrete that has varying amounts of nylon fibre added—0, 0.25, 0.50, 0.75, and 1 percent.IN 2018

d..E. Siva Subramanian (2016) found that nylon fibre reinforced concrete is significantly stronger than regular concrete. In December 2016, he submitted four concrete mix designs, one of which included nylon fibre, to the International Journal of Engineering Science and Research Technology.

e. Dinakar et al. (2008) evaluated the concrete's chemical resistance by subjecting it to chemical attack by submerging it in an acidic solution. The specimens were taken out of the curing tank after the 90-day curing period and their surfaces were cleaned with a soft nylon brush to get rid of any weak reaction products and loose debris. Initial weights were calculated, and specimens had numbered plastic tokens attached around them to serve as identification. The pH was kept constant throughout the specimens' immersion in a solution of H2SO4 at a concentration of 3%. To keep the concentration constant throughout the test period, the solution was changed at regular intervals. Up to 90 days of routine measurements of the specimens' mass and weight reductions were performed.

EXPERIMENTAL STUDY:

Cement: Cement is often in the form of a powder that, when mixed with water to make a paste, can then be moulded or poured to produce a solid mass. many organic substances that are employed as cements to adhere to or fix materials. These, however, fall under the category of adhesive, which by itself designates a building material. Portland cement is-the material that is most frequently used in-building. The main raw material is a blend of clay or shale and high-calcium lime stone, sometimes known as cement rock. Some cements may also contain blast-furnace slag, and this cement is known as Ordinary-Portland cement (OPC). The amount of-iron-oxide in cement determines its color.

S.NO.	PROPERTY	TEST RESULTS
1.	Normal consistency	31%
2.	Initial setting time(Minutes)	174 min
3.	Final setting time	287min
4.	Specific gravity	3.15
5.	Soundness(Le-chatlierExp)	1.30mm
6.	Compressive strength of cement(28days)	53Mpa
7.	Specific surface area	320m2/kg
8.	Fineness of cement by sieving Throughtsieve-No.9t(90tmicronst fortatperiodtoft15tmin.	2.38%

Fine aggregate: Sand, also known as fine aggregate, is a collection of mineral grains that are created when rocks crumble. The fine aggregate size is less than 4.75mm, and it can be made either naturally or artificially. Sand that has been removed from organic stuff and sorted out by water currents or winds across arid terrain. It's important to pay great attention to and keep track of the moisture content or absorption qualities. Natural sand derived from the Godavari River and complying to grading zone-III of table 3 of IS: 10262-2009 is used as the fine aggregate. Sands are often composed of quartz and other siliceous minerals.

Coarse aggregate: Crushed stone is used to make concrete that conforms with IS:383-1970 as coarse aggregate.The coarse aggregate size is larger than 4.75mm.. Generally the size of 20 mm coarse aggregate having the specific-gravity - 2.74 is used. It is free of impurities like dirt, mud, biological material, etc. The different qualities of the coarse aggregate are also examined.

Physical Properties of Fine and Coarse Aggregate

S. No.	Properties	Test results	
		Fine Aggregate	Coarse Aggregate
1.	Specific Gravity	2.62	2.85
2.	Bulk - Density (Kg/m^3) a) loose b) compacted	 1600 kg/m^3 1750 kg/m^3	1400 Kg/m^3 1580 Kg/m^3
3.	Fineness -Modulus	2.18	8.13

NYLON FIBER: A synthetic reinforcement material is nylon fibre. Short discrete lengths of nylon fibre with a length-to-diameter aspect ratio (or ratio) ranging from 20 to 100, with various cross sections, and that are sufficiently small to be dispersed randomly in a mixture of unhardened concrete using standard mixing techniques are referred to as nylon fibre for reinforcing concrete. A particular proportion of nylon fibre in concrete can result in qualitative changes in the material's physical characteristics, considerably enhancing resistance to cracking, impact, fatigue, and bedding, as well as other attributes including tenacity and durability.

Nylon fibre concrete flooring can offer the best resistance to bear heavy loads, whether they be dynamic or static, as well as the greatest resistance to minimize fractures in hardened concrete. You have the option of installing a joint-free floor if you choose to use nylon fibre concrete flooring. Joint-less floors feature fewer joints and can create regions without joints that are as wide as 40 or 50 m .

NYLON FIBER

Properties	Result
Material used	100% virgin fiber
Type of nylon	Monofilament
Color	White
Fiber Length - L (mm)	12mm
-Diameter - D (microns)	120 microns
Aspect Ratio-(l/d)	100
Melting Point	435 F (225°C)
Ignition Point	11000F
Electrical Conductivity of nylon	Low
Thermal conductivity of nylon	Low
Acid & Salt resistance of nylon	High
Alkali resistance	Excellent
Chemical resistance	Good
Absorption	3%

Young's Modulus	750 ksi
Specific gravity	0.91
Tensile strength	130 - 140 ksi
Density	675 kg/m³

Water : Concrete's strength is mostly a result of the use of water. Approximately 3/10th of its weight in water is needed for the entire hydration process. It has been demonstrated in practise that ordinary concrete must have a minimum water-cement ratio of 0.45. When water-reacts with-cement, cement paste is created, which then bonds with both coarse and fine particles. Using additional water causes segregation and bleeding, which weakens the concrete. However, the majority of the water will be absorbed by the fibre, which may prevent bleeding. If the water content is higher than allowed, bleeding may result. Concrete won't have the necessary workability if less water is used. The concrete must be mixed with potable water that is safe to drink and whose pH value varies from 6 to 9.

HYDROCHLORIC ACID (HCL):

Around 800 AD, alchemist Jabir ibn Hayyan (Geber) made the first know discovery of hydrochloric acid by common salts and vitriol (sulphuric acid).Chlorine and hydrogen, both of which are formed by the electrolysis of salt solutions, are the primary ingredients in the production of hydrochloric acid (HCl), however it can also be isolated as a by-product of several organic or inorganic reactions.

Hydrochloric-acid

EXPERIMENTAL STUDY:

Concrete mix design is the science of deciding relative proportions of ingredients of concrete like C,FA and CA ,in order to effectively attain the needed attributes.

In this study M25 grade and M30 grade were prepared based on IS1.262:2009.

QUANTITIES OF MATERIALS

Materal /Quantities	Grades	
	M25	M30
Cement	405.44 kg/m^3	405.48kg/m^3
Fine aggregate	726.06 kg/m^3	741.30kg/m^3
Coarse aggregate	1096.30 kg/m^3	1076.42kg/m^3
W/C ratio	0.5	0.49

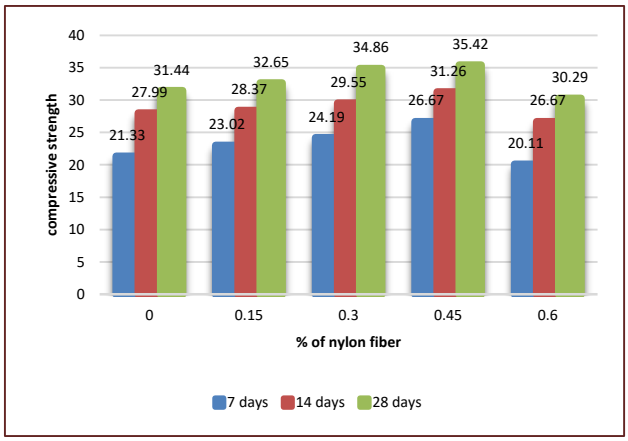
In this study , add nylon fiber with various percentages of 0.15%, 0.30%, 0.45%, 0.60%, mix to the M25 & M30 grade of concrete and cast the cubes of size (150*150*150mm), beams (500*100*100mm) & cylinders (300*150mm) ,these specimens cure in the portable water and acid (HCL) for a period of 7, 14, 28 days.

RESULTS AND DISCUSSIONS:

FOR CONCRETE GRADE M25 WITH WATER CURING

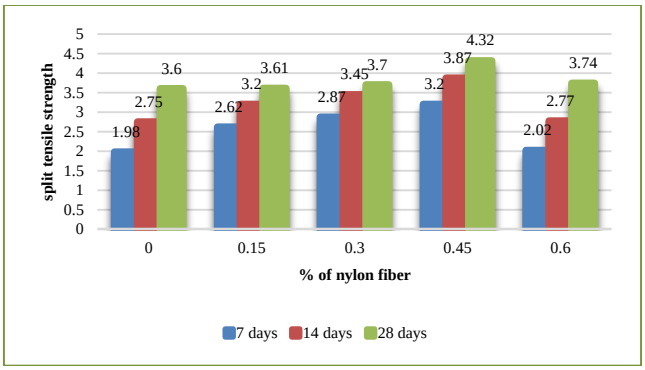
For the compressive strength, split tensile strength, flexural strength values cubes of size 150 x 150 x 150mm of M25 nylon fiber concrete and plain concrete were casted and tested for 7 days, 14 days and 28 days.

❖ **COMPRESSIVE STRENGTH TEST:**



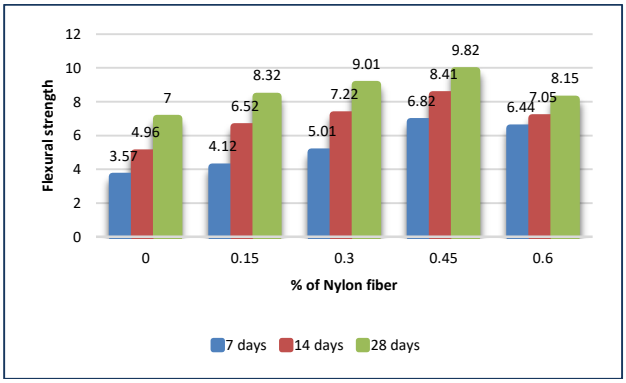
The Compressive Strength of nylon reinforced concrete increased by 1.12% at 0.45% fiber, compared to plain concrete.

❖ **SPLIT TENSILE STRENGTH TEST:**



The tensile strength of nylon reinforced concrete increased by 1.2% at 0.45% fiber, compared to plain concrete

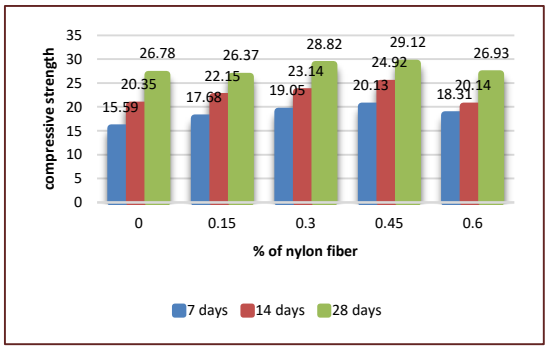
❖ ***LEXURAL STRENGTH TEST:***



The Flexural Strength of nylon reinforced concrete increased by 1.4% at 0.45% fiber, compared to plain concrete.

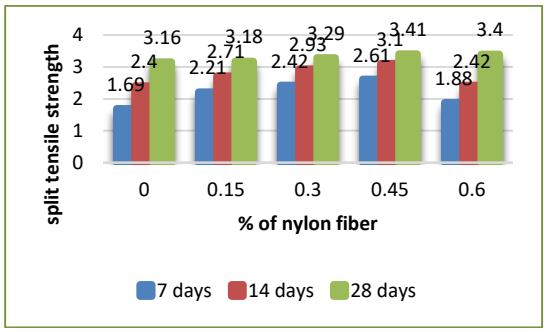
FOR CONCRETE GRADE M25 WITH ACID CURING

❖ ***Compressive Strength Test :***



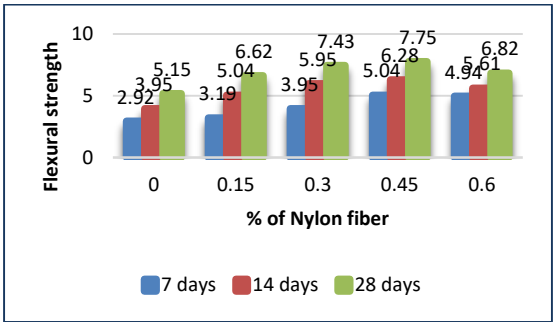
The compressive strength of nylon reinforced concrete increased by 1.08% at 0.45% fiber, compared to plain concrete.

❖ ***SPLIT TENSILE STRENGTH TEST :***



The tensile strength of nylon reinforced concrete increased by 1.07% at 0.45% fiber, compared to plain concrete.

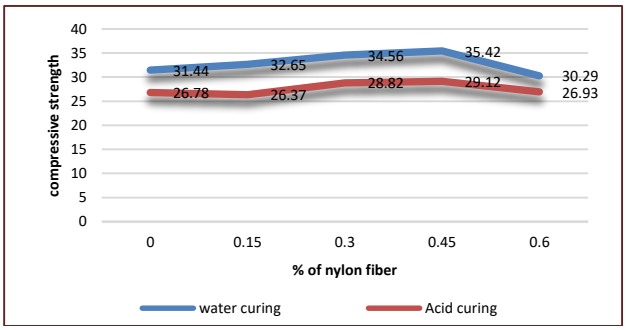
❖ **FLEXURAL *STRENGTH TEST:***



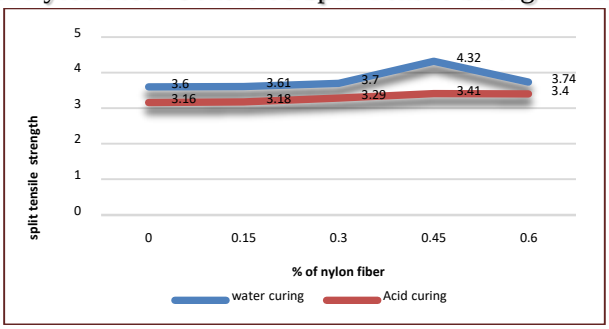
The Flexural Strength of nylon reinforcedconcrete increased by 1.5% at 0.45% fiber, compared to plain concrete.

➢ **A COMPARISON OF STREGTH OF SPECIMENS OF M25 GRADE WITH WATER AND ACID CURING :**

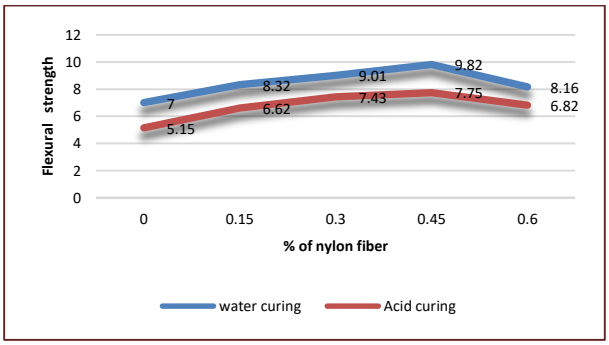
*A Performance Comparison Of Nylon Fiber Concrete's Compressive Strength With Water And Acid Curing



*A Performance Comparison of Nylon Fiber Concrete's Split Tensile Strength With Water And Acid Curing.



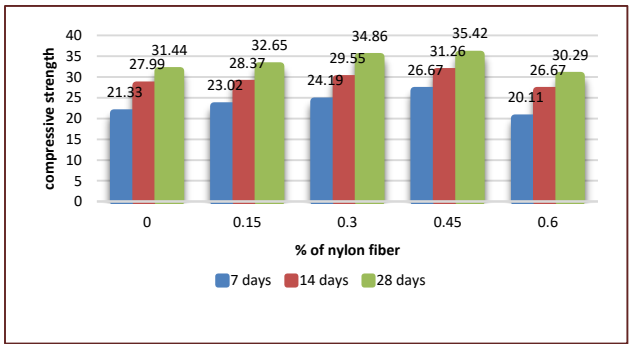
*A PERFORMANCE COMPARISON OF NYLON FIBER CONCRETE'S FLEXURAL STRENGTH WITH WATER AND ACID CURING



➢ **FOR M30 GRADE OF CONCRETE WITH WATER CURING**

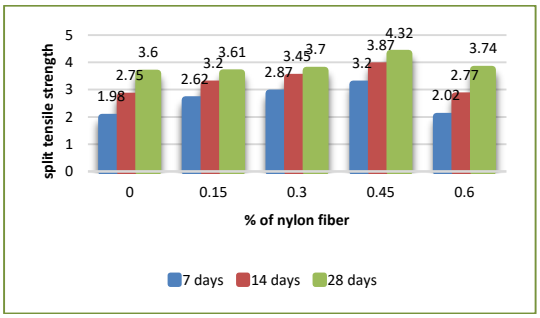
For the compressive strength, split tensile strength, flexural strength values cubes of size 150 x 150 x 150mm of M30 nylon fiber concrete and plain concrete were casted and tested for 7 days, 14 days and 28 days.

❖ **COMPRESSIVE STRENGTH TEST:**



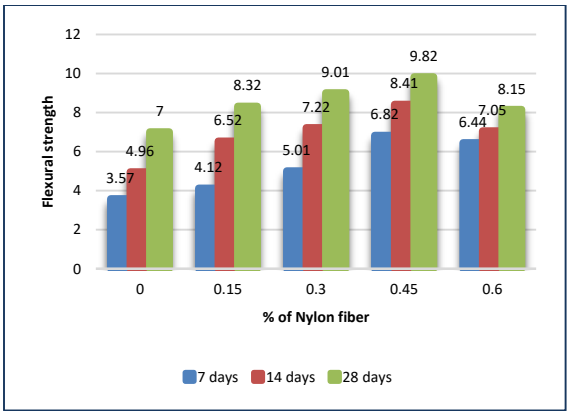
The compressive strength of nylon reinforced concrete increased by 1.09% at 0.45% fiber, compared to plain concrete.

❖ **SPLIT TENSILE STRENGTH TEST**



The tensile strength of nylon reinforced concrete increased by 1.09% at 0.45% fiber, compared to plain concrete

❖ **FLEXURAL STRENGTH TEST:**

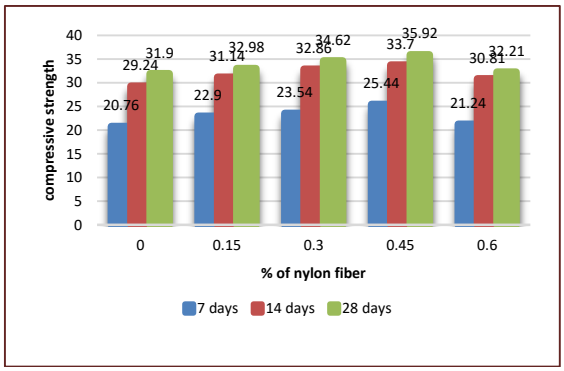


The flexural strength of nylon reinforced concrete increased by 1.09% at 0.45% fiber, compared to plain concrete.

➲ **FOR CONCRETE GRADE M30 WITH ACID CURING**

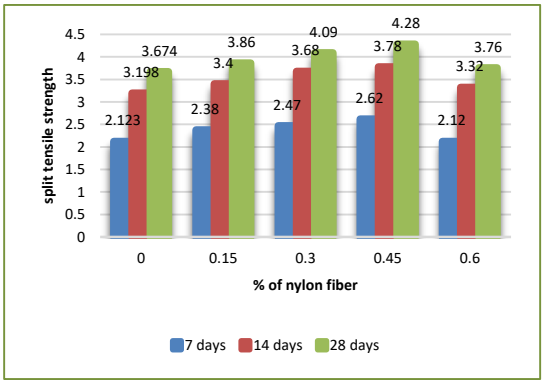
For the compressive strength, split tensile strength, flexural strength values cubes of size 150 x 150 x 150mm of M30 nylon fiber concrete and plain concrete were casted and tested for 7 days, 14 days and 28 days.

- ***COMPRESSIVE STRENGTH TEST:***



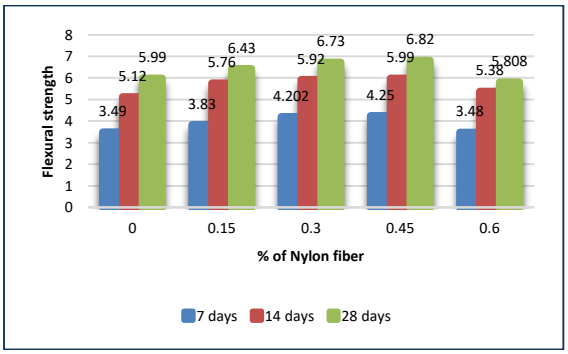
The compressive strength of nylon reinforced concrete increased by 1.16% at 0.45% fiber, compared to plain concrete.

- **SPLIT TENSILE STRENGTH TEST:**



The tensile strength of nylon reinforced concrete increased by 1.07% at 0.45% fiber, compared to plain concrete.

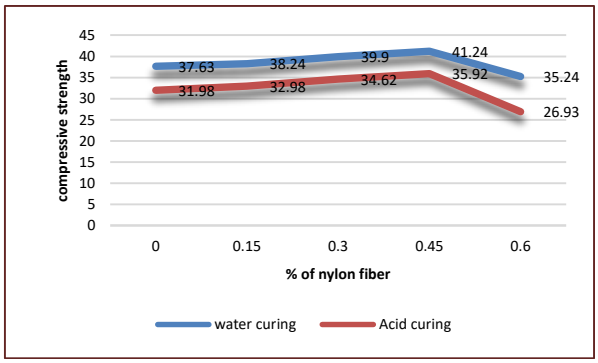
- **FLEXURAL STRENGTH TEST:**



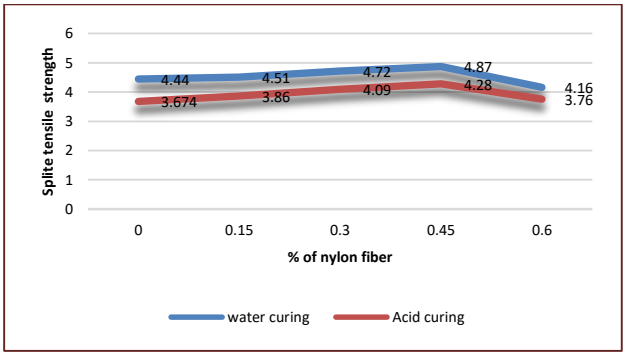
The flexural strength of nylon reinforced concrete increased by 1.13% at 0.45% fiber, compared to plain concrete.

➲ **A COMPARISON OF STREGTH OF M30 GRADE SPECIMENS WITH WATER AND ACID CURING :**

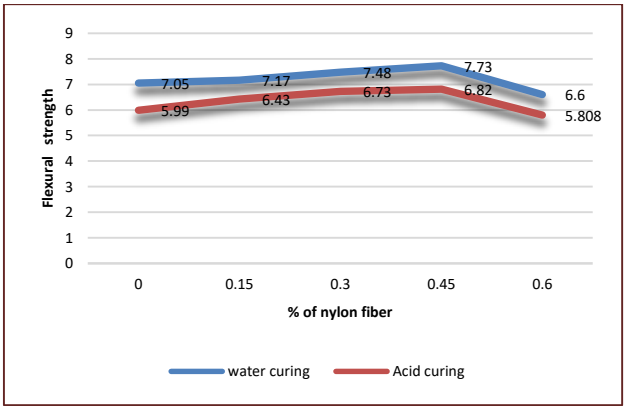
***** A PERFORMANCE COMPARISON OF NYLON FIBER CONCRETE'S COMPRESSIVE STRENGTH WITH WATER AND ACID CURING



*A PERFORMANCE COMPARISON OF NYLON FIBER CONCRETE'S SPLIT TENSILE STRENGTH WITH WATER AND ACID CURING



*A PERFORMANCE COMPARISON OF NYLON FIBER CONCRETE'S FLEXURAL STRENGTH WITH WATER AND ACID CURING



CONCLUSION

❖ The Compressive Strength of M25grade plain and nylon reinforced concrete with water and acid curing at 28 days, the strength varies as 1.17%,1.2%, 1.19%,1.2% and 1.12% at 0%,0.15%,0.3%,0.45% and 0.6% of Nylon respectively.

❖ The Split Tensile Strength of M25grade plain and nylon reinforced concrete with water & acid curing at 28 days, the strength varies as 1.13%,1.13%.1.12%,1.3% and 1.1% at 0%,0.15%,0.3%,0.45% and 0.6%.of Nylon respectively.

❖ The Flexural Strength of M25grade plain and nylon fiber concrete with water and acid curing at 28 days, the strength varies as 1.3%,1.2%.1.2%,1.26% and 1.19% at 0%,0.15%,0.3%,0.45% and 0.6%of Nylon respectively.

❖ At 0.6%, Compressive Strength , Split Tensile Strength and Flexural Strength, rate of decrease is low when compared at other percentages.

- The Compressive Strength of M30grade plain and nylon reinforced concrete with water and acid curing at 28 days, the strength varies as 1.17%,1.16%, 1.15%,1.14% and 1.0.91% at 0%,0.15%,0.3%,0.45% and 0.6% of Nylon respectively.
- The Split Tensile Strength of M30grade Plain and Nylon reinforced concrete with water and acid curing at 28 days, the strength varies as 1.2%,1.16%.1.15%,1.3% and 1.1% at 0%,0.15%,0.3%,0.45% and 0.6%.of Nylon respectively.
- Flexural strength of M30grade plain and nylon reinforced concrete with water and acid curing at 28 days, the strength varies as 1.17%,1.1%.1.3%,1.14% and 0.96% at 0%,0.15%,0.3%,0.45% and 0.6%of Nylon respectively.
- Finally, it's been observed that the strength of Nylon fiber concrete decreased with acid curing when compared to water curing. But with acid curing, the strength of Nylon fiber concrete is high when compared to plain concrete.

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