EVALUATE THE PERFORMANCE OF CONCRETE WITH ACRYLIC & CARBON NANO FIBRES

Project Report Submitted in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision of

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Abbreviations & Symbols	**Description**
FRC	Fibre Reinforced Concrete
F_{sp}	Splitting Tensile Strength
F	Flexural Strength
CA	Coarse Aggregate
MPa	Mega Pascal
kN	Kilo Newton

CERTIFICATE

This is to certify that the work which is being presented in the project title **“Evaluate the performance of Concrete with Acrylic & Carbon Nano Fibres”** in partial fulfillment of the requirements for the award of the degree of Bachelor of technology and submitted in Civil Engineering Department, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by **Rahul Ray (121652) & Avneesh Chaudhary (121715)** during a period from August 2015 to June 2016under the supervision of **Dr. Ashok Kumar Gupta,** Head of Department, Civil Engineering Department, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of my knowledge.

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RAHUL RAY

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DATE

ABSTRACT

Addition of fiber reinforcement in discrete form improves many engineering properties of concrete. Currently Fiber reinforced concrete (FRC) is a new structural material which is gaining increasing importance. Very little research work is being conducted in India using this new material. This report describes the use of synthetic fibers and the comparison of PCC & FRC is made on the basis of different mechanical properties.

Shrinkage cracking of concrete is a major problem in plain cement concrete especially in tropical regions. To overcome shrinkage cracking of plain concrete, the addition of synthetic fiber to the concrete mix is suggested. This report briefly discusses the effects of addition of acrylic and carbon nano fibre on the properties of concrete mix of 25 MPa.. Concrete mixes with fiber dosage 0.25%, 0.5%, 1% and 1.25% by volume fraction besides the control concrete mix were manufactured. Acrylic fibre and carbon nano fiber were used in this study. The properties such as workability, flexural strength & split tensile strength of the concrete were evaluated. The study suggested a significant increase in flexural strength. Further, an improved spilt tensile strength for the concrete mixes reinforced with fiber was also observed.

CHAPTER 1: INTRODUCTION

1.1 General

Concrete is a composite material composed of coarse aggregate bonded together with a fluid cement which hardens over time. Most concretes used are lime-based concretes such as Portland cement concrete or concretes made with other hydraulic cements, such as cimentfondu. However, road surfaces are also a type of concrete, asphalt concrete, where the cement material is bitumen, and polymer concretes are sometimes used where the cementing material is a polymer.

In Portland cement concrete (and other hydraulic cement concretes), when the aggregate is mixed together with the dry cement and water, they form a fluid mass that is easily molded into shape. The cement reacts chemically with the water and other ingredients to form a hard matrix which binds all the materials together into a durable stone-like material that has many uses. Often, additives (such aspozzolans or superplasticizers) are included in the mixture to improve the physical properties of the wet mix or the finished material. Most concrete is poured with reinforcing materials (such as rebar) embedded to provide tensile strength, yielding reinforced concrete.

This stone like material is a brittle material which is strong in compression but very weak in tension. This weakness in the concrete makes it to crack under small loads, at the tensile end. These cracks gradually propagate to the compression end of the member and finally, the member breaks. The formation of cracks in the concrete may also occur due to the drying shrinkage. These cracks are basically micro cracks. These cracks increase in size and magnitude as the time elapses and the finally makes the concrete to fail.

The formation of cracks is the main reason for the failure of the concrete. To increase the tensile strength of concrete many attempts have been made. One of the successful and most commonly used method is providing steel reinforcement. Steel bars, however, reinforce concrete against local tension only. Cracks in reinforced concrete members extend freely until encountering are bar. Thus need for multidirectional and closely spaced steel reinforcement arises. That cannot be practically possible. Fibre reinforcement gives the solution for this problem.

So to increase the tensile strength of concrete a technique of introduction of fibres in concrete is being used. These fibres act as crack arrestors and prevent the propagation of the cracks. These fibres are uniformly distributed and randomly arranged. This concrete is named as fibre reinforced concrete.

The main reasons for adding fibres to concrete matrix is to improve the post cracking response of the concrete, i.e., to improve its energy absorption capacity and apparent ductility, and to provide crack resistance and crack control. Also, it helps to maintain structural integrity and cohesiveness in the material. The initial researches combined with the large volume of follow up research have led to the development of a wide variety of material formulations that fit the definition of Fibre Reinforced Concrete.

1.2 Fibre Reinforced Concrete

Fibre reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. So we can define fibre reinforced concrete as a composite material of cement concrete or mortar and discontinuous discrete and uniformly dispersed fibre.

Fibre is discrete material having some characteristic properties. The fibre material can be anything. But not all will be effective and economical. Some fibres that are most commonly used are:

1.2.1 Glass Fibre Reinforced concrete (GFRC)

Glass fiber reinforced concrete has been successfully used since the last 25 years for concrete reinforcement, in addition to steel. GFRC is being manufactured into big panels with a simple configuration or into intricate shapes by using special techniques. Originally, GFRC components were anchored directly with the buildings by the use of metal studs. It was revealed that GFRC shifts considerably due to which the direct anchors are being replaced by slip anchors. Several structures use GFRC for dissimilar facing like ceramic tiles, bricks, and architectural purposes.

FIGURE 1: GFRC

1.2.2 Steel Fibre Reinforced Concrete (SFRC)

Steel fibre reinforced concrete is a composite material that can be sprayed. It consists of hydraulic cements with steel fibers that are dispersed randomly and possess a rectangular cross-section. The steel fibres reinforce concrete by withstanding tensile cracking. The flexural strength of fiber reinforced concrete is greater than the un-reinforced concrete. Reinforcement of concrete by steel fibres is isotropic in nature that improves the resistance to fracture, disintegration, and fatigue. Steel fibre reinforced concrete is able to withstand light and heavy loads.

FIGURE 2: SFRC

1.2.3 Natural fibre reinforced concrete (NFRC)

It consists of cellulose fibers that are processed from pine trees and wheat straws. This category is also producing good results. The recycled carpet waste has been successfully used for concrete reinforcement by using the waste carpet fibers.

1.2.4 Asbestos Fibres

These fibers are cheap and provide the cement with mechanical, chemical and thermal resistance, although the asbestos fiber reinforced concrete appears to have low impact strength.

FIGURE 3: ASBESTOS

1.2.5 Carbon Fibres

These fibers have been recently used due to their very high modulus of elasticity and flexural strength. Characteristics such as strength and stiffness are better than those of steel fibers, although they are more susceptible to damage.

FIGURE 4: CONCRETE CRACK FAILURE

1.2.6 Synthetic Fibres

In today's world, synthetic fibers are mostly used in various fields. There are many types of synthetic fibers and few are discussed below, namely, polypropylene fiber, nylon fiber and polyester fiber.

i).Polypropylene Fiber Reinforced concrete: Of the synthetic fibers available, polypropylene is the most widely used in ready mixed concrete. Polypropylene fibers are hydrophobic, so they don't absorb water and have no effect on concrete mixing water requirements. They come as either fibrillated bundles or monofilaments. To produce fibrillated fibers, manufacturers extrude the polypropylene in sheets that are stretched and slit. The result is a mesh of interconnected fiber strands rectangular in cross section.

Manufacturers cut the strands to specified lengths and separate them into bundles. Fiber lengths range from 1 ⁄4 to 21 ⁄2 inches. When added to concrete during mixing, the fibrillated fibers open into a network of linked fiber filaments that mechanically anchor to the cement paste. The graded fibers reportedly disperse more thoroughly into all areas of the cement paste during mixing. Monofilament fibers are fine, cylindrical strands that separate during mixing. Because monofilament fibers are smooth and have a small surface area, they don't anchor into the cement matrix as well as fibrillated fibers. With fibrillated fibers, cement paste penetrates into the network of fiber filaments resulting in better mechanical anchoring to the concrete. Research shows that lower volumes of fibrillated fibers than of monofilament fibers are needed to improve the post-cracking load carrying capacity and ductility of concrete. Some manufacturers recommend using monofilament fibers for relatively short term benefits, such as plastic shrinkage crack control during the first few hours after concrete placement.

ii). Polyester The fiber bundles come only in monofilament form in lengths from 3 ⁄4 to 2 inches like polypropylene, polyester fibers are hydrophobic. However, they have a tendency to disintegrate in the alkaline environment of portland cement concrete. To retard this degradation, manufacturers of polyester fibers coat the fibers to resist alkali attack. Butthe long-term performance of the coated fibers has not been determined.

FIGURE 5: POLYESTER

iii). Nylon. Like poly-ester fibers, nylon fibers come only in monofilament form. They are of hydrophilic nature. They retain a natural moisture balance of 4.5%. Because of this strong affinity to water, nylon fibers bond chemically to the concrete matrix. The bond of polypropylene and polyester fibers is only mechanical. Nylon fiber manufacturers also report that their fibers have higher aspect ratios than those made of polypropylene. Therefore, they can be added in smaller dosages to produce the same reinforcing effects.

FIGURE 6: NYLON

1.3 History

The use of fibres to increase the structural properties of construction material is not a new process. From ancient times fibres were being used in construction. In BC, horse hair was used to reinforce mortar. Egyptians used straw in mud bricks to provide additional strength. Asbestos was used in the concrete in the early 19th century, to protect it from formation of cracks. But in the late 19th century, due to increased structural importance, introduction of steel reinforcement in concrete was made, by which the concept of fibre reinforced concrete was over looked for 5-6 decades. Later in 1939 the introduction steel replacing asbestos was made for the first time. But at that period it was not successful. From 1960, there was a tremendous development in the FRC, mainly by the introduction of steel fibres. Since then use of different types of fibres in concrete was made. In 1970's principles were developed on the working of the fibre reinforced concrete. Later in 1980's certified process was developed for the use of FRC. In the last decades, codes regarding the FRC are being developed.

1.3.1 The Shortcoming Of Steel Reinforcement

The relationship between steel and concrete has long been regarded as a major stepping stone in modern construction. Concrete is strong in compression but weak in tension and brittle in nature. To compensate steel is added to concrete to provide tensile strength. Traditional steel reinforcement is able to distribute the tensile strain forces that cause concrete to crack and ultimately fail. While this system has been successful for many years there are a number of associated drawbacks.

Steel is expensive to purchase, transport and store. The placement of steel consumes significant time and labour costs, often requiring placement in difficult and dangerous locations. Most serious of all, steel is highly corrosive in nature which commonly leads to concrete cancer. Concrete cancer refers to the corrosion of reinforcement leading to failure of the structure. Concrete cancer, or perhaps we should more accurately say steel cancer, is extremely expensive to repair often requiring demolition of the structure.

1.3.2 The Introduction Of Synthetic Fibres

Like us, many engineers and designers believe the solution to these problems lie in alternatives to traditional steel reinforcement. While fibres such as horse hair and straw were commonly used in ancient times, the first modern alternative was the use of asbestos fibres in the early 1900's. The need to replace asbestos fibres in the early 1950's gave rise to the development of composite materials and by the 1970's steel fibre reinforcement had been accepted as a viable alternative to traditional reinforcement. Steel fibre however suffered the same problems as traditional steel. The high dose rates required for changes to be made to the concrete mix and the handling steel fibres often results in puncture wounds.

Research continued into viable alternatives that could solve steel's core problems of cost and durability. The most promising fibres developed during this period were micro and macro synthetic fibres. Micro synthetic fibres are 6 to 20 mm long, tens of microns in diameter, have a texture similar to horse hair and are typically dosed at 1 to 2 kg/m3. Micro fibres became widely accepted as a control for plastic shrinkage and for passive fibre protection and anti-spalling. Unfortunately, micro fibres offered no structural benefit to concrete and could not be used to replace steel reinforcement. While promising, early macro synthetic fibres did not have sufficient strength to be a viable alternative to steel reinforcement. However, advances in manufacturing techniques and material properties during the 1980's and early 1990's in the textile and fabric industries saw the development of the first viable macro synthetic fibres.

1.3.3 Structural Synthetic Fibres

Macro synthetic fibres in the 1990's were the first synthetic fibre to offer structural benefits to concrete and were the first viable alternative to crack control mesh in concrete. Macro synthetic fibres are similar in size to steel fibre and provide concrete with the same and often higher level of post crack flexural capacity as steel fibre or mesh. Macro fibres are typically between 30 and 65mm long, dosed between 2.5kg and 10kg m/3 and range between 400 and 700 MPa. Macro synthetic fibres are manufactured using a variety of synthetic materials, with polyolefin based fibres showing the best results. BarChip macro synthetic fibres offer many benefits over steel mesh or steel fibre reinforcement.

- Significant price reduction
- Long term durability – corrosion free
- Post crack load capacity equivalent to SL82 mesh at regular dose rates
- Improved concrete ductility
- Significantly improves shrinkage and temperature crack control
- Eliminated bending, cutting and placement of steel mesh, increasing efficiency and productivity
- Safer and lighter to handle than steel
- Delivered to site ready mixed from the concrete plant
- Reduced carbon footprint

One of the first widespread adoptions of macro synthetic fibres occurred when EPC introduced BarChip structural synthetic fibre to the Australian mining industry. At the time, steel fibre reinforcement was used as shotcrete reinforcement in most Australian underground mines. Steel fibres damaged equipment, caused rebound injury and required significant maintenance due to corrosion. EPC's BarChip eliminated all these problems and delivered significant cost benefits. The Australian mining industry quickly adopted macro synthetic fibres into their shotcrete design and now over 90% of underground mines in Australia specify macro synthetic fibre reinforcement.

1.3.4 Codes And Standards

During this time the use of macro synthetic fibres had begun to expand outside of the mining shotcrete industry. In Europe and Japan structural synthetic fibres were used as shotcrete support for civil tunnel applications and as crack control reinforcement in commercial flooring and slab on grade applications. In Europe alone EPC supplied BarChip structural fibres as the shotcrete reinforcement in over 50 tunnel projects.

The increased use of macro synthetic fibre led to the development of a number of testing standards, technical guides and specifications. These included the ASTM C1550 Round Determinate Panel Test, The EURONORM EN-14448 EFNARC Panel Test, The UK

Concrete Society's Technical Report No. 65, British Standard EN14889, Fibres for Concrete, Part 2 and Eurocode 2.

1.3.5 Possible Applications

As structural macro synthetic fibres have been further tested and the capabilities better understood the viable applications have grown accordingly. EPC now supplies BarChip structural macro synthetic fibre into nearly every sector of the construction industry. BarChip structural synthetic fibre is used extensively for shotcrete reinforcement and as a replacement for crack control mesh in industrial floors, engineered slab on grade and concrete paving. BarChip is used extensively in precast applications including segmental linings for tunnels. BarChip is used as a crack control in white topping roadways and in railway track slab.

1.4 Properties of Fibre Concrete

Properties of concrete is affected by many factors like properties of cement, fine aggregate, coarse aggregate. Other than this, the fibre reinforced concrete is affected by following factors:

• Type of fibre

• Aspect ratio

• Quantity of fibre

• Orientation of fibre

1.4.1 Type of fibre

A good fibre is the one which possess the following qualities:

• Good adhesion within the matrix.

• Adaptable elasticity modulus (sometimes higher than that of the matrix)

• Compatibility with the binder, which should not be attacked or destroyed in the long term

• An accessible price, taking into account the proportion within the mix

• Being sufficiently short, fine and flexible to permit mixing, transporting and placing

• Being sufficiently strong, yet adequately robust to withstand the mixing process.

1.4.2 Aspect ratio

Aspect ratio is defined as the ratio of length to width of the fibre. The value of aspect ratio varies from 30 to 150. Generally the increase in aspect ratio increases the strength and toughness till the aspect ratio of 100. Above that the strength of concrete decreases, in view of decreased workability and reduced compaction. From investigations it can be found out that good results are obtained at an aspect ratio around 80 for steel fibres. Keeping that in view we have considered steel hooked end fibres with aspect ratio of 80 (Length 60 mm and Diameter 0.75 mm).

1.4.3 Fibre quantity

Generally quantity of fibres is measured as percentage of cement content. As the volume of fibres increase, there should be increase in strength and toughness of concrete. Regarding our fibre, we hope that there will be an increase in strength, with increase in fibre content. We are going to test for percentages of 0.25, 0.5. 1.0 and 1.25.

1.4.4 Orientation of fibre

The orientations of fibres play a key role in determining the capacity of concrete. In RCC the reinforcements are placed in desired direction. But in FRC, the fibres will be oriented in random direction. The FRC will have maximum resistance when fibres are oriented parallel to the load applied.

1.5 Fibre Mechanism

Fibre work with concrete utilizing two mechanisms: the spacing mechanism and the crack bridging mechanism. The spacing mechanism requires a large number of fibres well distributed within the concrete matrix to arrest any existing micro crack that could potentially expand create a sound crack. For typical volume of fractions of fibres utilizing small diameter of fibres or micro fibres can ensure the required no of fibres for micro crack arrest. The second mechanism termed crack bridging requires larger straight fibres with adequate bond to concrete. Steel fibres are considered a prime example of this fibre type that is commonly referred as large diameter fibres or micro fibres.

1.6 Bridging Action

Pullout resistance of fibres (dowel action) is important for efficiency. Pullout strength of fibres significantly improves the post-cracking tensile strength of concrete. As an FRC beam or other structural element is loaded, fibres bridge the cracks. Such bridging action provides the FRC specimen with greater ultimate tensile strength and, more importantly, larger toughness and better energy absorption.

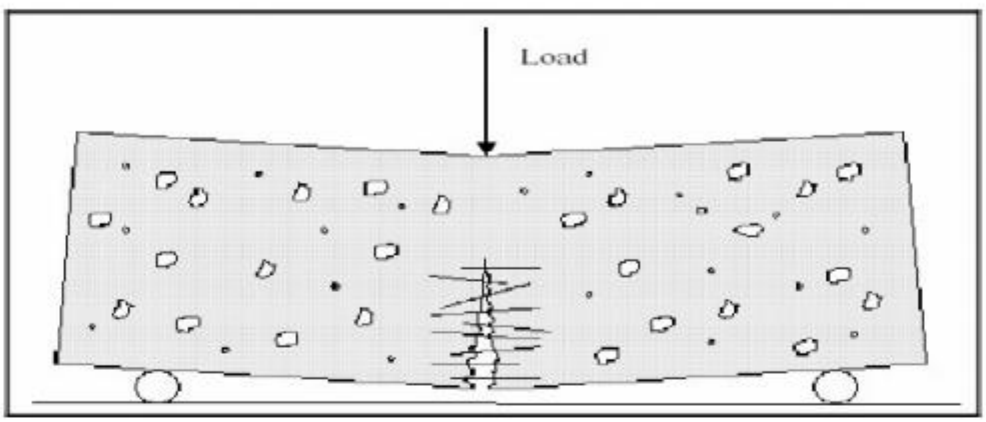

FIGURE 7: BRIDGING ACTION

1.7 Workability

A shortcoming of using fibres in concrete is reduction in workability. Workability of FRC is affected by fibre aspect ratio and volume fraction as well the workability of plain concrete.

As fibre content increases, workability decreases. Most researchers limit volume of fibres to 4.0% and aspect ratio to 100 to avoid unworkable mixes. In addition, some researchers have limited the fibre reinforcement index [volume of fibres as % ×aspect ratio] to 1.5 for the same reason. To overcome the workability problems associated with FRC, modification of concrete mix design is recommended. Such modifications can include the use of additives.

CHAPTER 2: LITERATURE REVIEW

1.Topic:- Effect of microsilica and acrylic polymer treatment on the ageing of GRC.

By:-Peter J.M. Bartos, Wenzhong Zhu

Abstract

Microsilica and acrylic polymer dispersions were used in different types of fibre treatments and matrix modifications. The effects of the various treatments/modifications on the flexural properties, the failure modes and the interfacial changes after different periods of ageing were investigated. The fibre treatment was found to be more effective in controlling the interfacial changes and properties of the aged composites, compared to the matrix modification. The relative effectiveness of the different fibre treatments, however, depended greatly on the bundle size of the fibre reinforcement used.

A new technique based on an unique microindentation apparatus was developed and used to carry out micro-strength testing in the fibre-matrix interfacial zone and particularly within the fibre bundle. Results suggested that a soft/flexible fibre bundle core combined with a strong bonding at the fibre-matrix interface was desirable for the optimal improvement of the long term performance of the composites.

2.Topic :- Laboratory and industrial investigations on hybrid of acrylic and glass short fibers as an alternative for substituting asbestos in Hatschek process

By:-M. Jamshidi , A.A. Ramezanianpour

Abstract

Asbestos fibers have been used in cement based materials to improve tensile strength and controlling crack formation and propagation. Asbestos–cement sheets are produced by the Hatschek technique in a number of developing countries.

Due to the health and safety issues in the asbestos products, attempts have been made to substitute other fibers using the Hatschek system for cement sheets. The quality and homogeneity of the products depend on the type of fibers and varies substantially in the Hatschek system during production.

In this investigation acrylic and glass fibers in separate and hybrid forms were used for manufacture of flat and corrugated sheets. Higher strength and ductility were obtained for the sheets containing glass fibers. Performance was even better when hybrid system of acrylic and glass fibers was used. The hybrid system was used for production of fiber–cement sheets in factory. This system is proposed as an appropriate alternative for substituting asbestos in the Hatschek process.

3.Topic:- Acrylic fibres as reinforcement for cement pastes

(Instituto de Ciencias de la Construcción 'Eduardo Torroja' (CSIC), Aptdo. 19002, 28080 Madrid, Spain)

By:- **T. Amat,M.T. Blanco,A. Palomo**

Abstract

The possibility of employment of acrylic fibres as reinforcing material in cement paste, mortars and concretes has been studied by the authors of the present paper according to two features characterizing this kind of composite:

(a) Reinforcing capacity of poliacylonitrile fibres

(b) Resistance to chemical attack of the aforementioned fibres

The present paper is the first part of a study projected on the long run; accordingly, in the future more data could be furnished in order to study more closely some specific aspects that can complement these first results. Thus for instance, in pastes of Portland cement, it has been proved that the presence of this type of fibre improves their impact resistance upto around 30–40 times whereas flexural resistances for 1·5% wt of addition of fibres have an increase, with respect to those obtained for pure paste, of around 50% in some cases. Simultaneously, it has been proved that the chemical resistance or attackability of acrylic fibres in high alkaline media is quite good.

4. Topic:-Effect of acrylic fibres geometry on physical, mechanical and durability properties of cement mortars.

(Centre of Materials and Building Technologies (C-MADE), University of Beira Interior, Calçada Fonte doLameiro, 6201-001 Covilhã, PortugalReceived 31 December 2010, Revised 27 July 2011, Accepted 28 July 2011, Available online 23 August 2011**)**

By:-Luiz A. Pereira-de-Oliveira ,João P. Castro-Gomes, Miguel C.S.Nepomuceno

Abstract

This paper presents the results of an experimental investigation to verify the feasibility of using acrylic textile fibre to improve cement based mortars properties. The assessment of acrylic fibresinfluence on mortars properties was performed comparing the physical, mechanical and durability behaviour with mortars produced using glass and polypropylene fibres. The influence of the mixing procedures was also investigated. Effects of acrylic fibre aspect ratio (l/d) and volume fraction (V_f) on mortar bulk density, compressive strength, flexural strength, water absorption and plastic shrinkage were investigated. For this purpose, acrylic fibres having six different l/d ratios 93, 148, 222, 278, 444 and 833 were used and the volume percentage of fibres were added to mortar mixes was of 0.2%, 0.5% and 1.0%. The mortar plastic shrinkage was also studied on slabs casted with 0.5%, 0.2%, 0.1% and 0.05% acrylic fibres volume.

It was found that acrylic fibre reinforced mortars have physical, mechanical and durability related properties similar to the mortar reinforced with glass or polypropylene fibres. These results indicate that there is a potential technical feasibility of using this type of fibres in cementitious composites.

5. Topic:-Cements reinforced by acrylic fibers. Infrared studies. I. Hydration and hydrolysis processes in the fibers.

(Inst. de CC. de la Construcción E. Torroja. 28033 Madrid.Spain)(Available online 12 February 2003)

By:- Fernando Accion,JavierGobantes,María Teresa Blanco

Abstract

During a study of different treatments of fibers employed to reinforce cements, IR spectra of acrylonitrile-methyl acrilate copolymer in solid state, untreated and treated with different media (distilled water, basic aqueous solutions) have been recorded. These spectra have been analyzed and assigned on the basis of spectral comparison with spectra of analogous ones previously studied. Treated fiber spectra exhibit many bands due to the existence of water molecules in the fiber structure. Hydrolysis and hydration processes have been formulated, which explain satisfactorily the spectral assignment proposed.

6. Topic:- Mechanical properties of fiber reinforced lightweight concrete composites.

(Assistant Prof. of Civil Eng., Arizona State Univ., Tempe, AZ 85 87-5306, USA)

By:- M. Perez-Pena,B. Mobasher

Abstract

Hybrid composites with variable strength/toughness properties can be manufactured using combinations of brittle or ductile mesh in addition to brittle and ductile matrix reinforcements. The bending and tensile properties of thin sheet fiber cement composites made from these mixtures were investigated. Composites consisted of a woven mesh of either polyvinyl chloride (PVC) coated E-glass or polypropylene (PP) fibers for the surface reinforcement. In addition, chopped polypropylene, acrylic, nylon, and alkali-resistant (AR) glass fibers were used for the core reinforcement.

It is shown that by controlling fiber contents, types, and combinations, design objectives such as strength, stiffness and toughness, can be achieved. Superior post-cracking behavior was measured for composites reinforced both with glass mesh and PP mesh. Load carrying capacity of PP mesh composites can be increased with the use of 1% or higher chopped PP fibers. Glass mesh composites with short AR glass fibers as matrix reinforcement indicate an increased matrix cracking strength and modulus of rupture. Combinations of PP

mesh/short AR glass did not show a substantial improvement in the matrix ultimate strength. An increased nylon fiber surface area resulted in improved post peak response.

7. Topic:-Synthetic fibre-reinforced concrete.

(Centre for Building Studies, Concordia University, Montreal, Quebec H3G 1M8, Canada)

By:-Zhihong Zheng, Dorel Feldman

Abstract

With the growing interest in the use of synthetic fibre-reinforced concrete in the construction industry, attempts to clarify its performance have become important. The characteristics of various synthetic fibres and the behaviour of concrete reinforced with each of these fibres are discussed here. The present paper reviews current research concerning the performance of synthetic fibre-reinforced concrete based on polyethylene (PE), polypropylene (PP), acrylics (PAN), poly(vinyl alcohol) (PVA), polyamides (PA), aramid, polyester (PES) and carbon reinforcements which are considered to be promising for the development of cementitious composite materials.

8.Topic:-Carbon fibre-cement adhesion in carbon fibre reinforced cement composites.

(Department of Chemical Engineering and Composite Materials and Structures Center, Michigan State University, East Lansing, MI 48824, USA)(Available online 23 April 2003)

By:- B.K. Larson,L.T. Drzal,P. Sorousian

Abstract

The addition of small amounts of short carbon fibres to cement causes a great increase in the composite material toughness and tensile, flexural, and impact strength. In order to understand how cement properties are improved by carbon fibres and to understand the

level of adhesion and interfacial failure mode which are necessary to obtain optimum carbon fibre reinforced cement (CFRC) properties, various admixtures were included in cement and CFRC. Their effects on the carbon fibre-cement adhesion and the composite material properties were determined using fibre pull-out and composite material flexural tests. The addition of latex to CFRC, and hot water curing of CFRC dramatically increase fibre-matrix adhesion. Both latex (with an anti-foam agent) and hot water curing increase flexural strength by 40% over adhesion changes the failure mode from fibre pull-out to fibre rupture. Optimum strength and toughness of CFRC result from an intermediate level of fibre-matrix adhesion.

9. Topic:-A statistical tensile model of fibre reinforced cementitious composites

(Department of Civil Engineering Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA)(Available online 23 April 2003)

By:- Y. Wang,S. Backer,V.C. Li

Abstract

A statistical model has been developed to predict the tensile constitutive relationship of FRC from fibre and matrix properties and geometries. This tensile relation for FRC is also used to predict the load-deformation relations for the compact tension test and the flexural test configurations. Theoretical load-deformation relations of FRC were compared with results from these tests and good qualitative agreement was obtained for different FRC. There still exists a difference between the magnitudes of the theoretical and the experimental data. Possible sources of this discrepancy are discussed as a basis for ongoing theoretical and experimental studies aimed at reducing this discrepancy.

10. Topic:- Surface treated polypropylene (PP) fibres for reinforced concrete

(AIDICO Technological Institute of Construction, Marble Technical Unit, Camí de Castella 4, 03660 Novelda. Alicante, Spain)

(Received 8 December 2011, Accepted 8 August 2013)

By:-Angel M. López-Buendía, María Dolores Romero-Sánchez, Verónica Climent, CeliaGuillem

Abstract

Surface treatments on a polypropylene (PP) fibre have contributed to the improvement of fibre/concrete adhesion in fibre-reinforced concrete. The treatments to the PP fibre were characterized by contact angle measurements, ATR-IR and XPS to analyse chemical alterations. The surface topography and fibre/concrete interaction were analysed by several microscopic techniques, namely optical petrographic, and scanning electron microscopy. Treatment modified the surface chemistry and topography of the fibre by introducing sodium moieties and created additional fibre surface roughness. Modifications in the fibre surface led to an increase in the adhesion properties between the treated fibres and concrete and an improvement in the mechanical properties of the fibre-reinforced concrete composite as compared to the concrete containing untreated PP fibres. Compatibility with the concrete and increased roughness and mineral surface was also improved by nucleated portlandite and ettringite mineral association anchored on the alkaline PP fibre surface, which is induced during treatment.

CHAPTER 3: OBJECTIVES

The aim of our project is to use the Synthetic Fibres as fibre reinforcement to concrete.

Our objective is to add the fibres to the concrete and to study the strength properties of concrete with the variation in fibre content. i.e., to study the strength properties of concrete (M25 Grade) for fibre content of 0.25%, 0.5%, 1.0% and 1.25% at 7 and 28 days.

The strength properties being studied in our project are as follows:

1. Split tensile Strength

2. Flexural strength

These properties are then compared to the plain cement concrete.

3.1 Tests to be conducted

3.1.1 Split Tensile Test

The splitting tests are well known indirect tests used for determining the tensile strength of concrete sometimes referred to as split tensile strength of concrete. The test consists of applying a compressive line load along the opposite generators of a concrete cylinder placed with its axis horizontal between the compressive platens. Due to the compression loading a fairly uniform tensile stress is developed over nearly 2/3 of the loaded diameter as obtained from an elastic analysis. The magnitude of this tensile stress Osp (acting in a direction perpendicular to the line of action of applied loading) is given by the formula (IS : 5816-1970):

$$\mathbf{F_{sp} = 2P/\prod dl = 0.637\ P/dl}$$

P= max. load(N)

d= diameter of the cylindrical beam(mm)

l= length of the cylinder(mm)

FIGURE 8: CTM

3.1.2 Flexural Test (Centre point load method)

Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending. It is measured by loading 100x100mm concrete beams with a span length at least three times the depth. The flexural strength is expressed as Modulus of Rupture (MR) in psi (MPa) and is determined by standard test methods ASTM C 78 (third-point loading) or ASTM C 293 (center-point loading).

Flexural Strength of Concrete Flexural MR is about 10 to 20 percent of compressive strength depending on the type, size and volume of coarse aggregate used. However, the best correlation for specific materials is obtained by laboratory tests for given materials and mix design. The MR determined by third-point loading is lower than the MR determined by center-point loading, sometimes by as much as 15%.

$$\mathbf{F=Pl/bd^2}$$

P= max load(N), **l**= length of beam(mm),

b= width of beam(mm), **d**= depth of beam(mm)

FIGURE 9: UTM

CHAPTER 4: PLANNING OF LABORATORY WORK

4.1 Planning of Materials

4.1.1 Aggregates

- Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. Earlier, aggregates were considered as chemically inert materials but now it has been recognized that some of the aggregates are chemically active and also that certain aggregates exhibit chemical bond at the interface of aggregate and paste. The mere fact that the aggregates occupy 70–80 per cent of the volume of concrete, their impact on various characteristics and properties of concrete is undoubtedly considerable. To know more about the concrete it is very essential that one should know more about the aggregates which constitute major volume in concrete. Without the study of the aggregate in depth and range, the study of the concrete is incomplete. Cement is the only factory made standard component in concrete. Other ingredients, namely, water and aggregates are natural materials and can vary to any extent in many of their properties. The depth and range of studies that are required to be made in respect of aggregates to Aggregates are used as per the availability nearby.

  FINE AGGREGATE- Aggregate most of which passes 4.75mm IS Sieve. Fine aggregate resulting from the natural disintegration of rock and which has been deposited by streams or glacial agencies. We collected the sand from the civil department of the college campus. Sand used is of zone II.

  COARSE AGGREGATE -- Aggregate most of which is retained on 4.75 mm IS Sieve. We used the size between 10 mm to 20 mm.

- We collected the aggregates from the civil department of the college campus.

- As per the assumptions taken in mix design, we have collected 20mm maximum size aggregates by the help of sieve analysis.

Sieve size	% Retained on each sieve		Cumulative % Retained		Cumulative % passing	
	20 mm CA (50%)	10 mm CA (50%)	20 mm CA	10 mm CA	20 mm CA	10 mm CA
20 mm	0	0	0	0	100	100
10 mm	22.24	22.24	22.24	22.24	77.76	77.76
4.75 mm	61.88	61.88	84.12	84.12	15.88	15.88

TABLE 1: AGGREGATE SIEVE ANALYSIS

4.1.2 Cement

Portland cement is the most common type of cement in general use around the world, used as a basic ingredient of concrete, mortar, stucco, and most non-specialty grout. It was developed from other types of hydraulic lime in England in the mid 19th century and usually originates from limestone. It is a fine powder produced by heating materials in a kiln to form what is called clinker, grinding the clinker, and adding small amounts of other materials. Several types of Portland cement are available with the most common being called ordinary Portland cement (OPC) which is grey in color, but a white Portland cement is also available.

ASTM C150 defines Portland cement as "hydraulic cement (cement that not only hardens by reacting with water but also forms a water-resistant product) produced by pulverizing clinkers which consist essentially of hydraulic calcium silicates, usually containing one or more of the forms of calcium sulphate as an inter ground addition." The European Standard EN 197-1 uses the following definition:

Portland cement clinker is a hydraulic material which shall consist of at least two-thirds by mass of calcium silicates (3 $CaO \cdot SiO_2$ and 2 $CaO \cdot SiO_2$), the remainder consisting of aluminium- and iron-containing clinker phases and other compounds. The ratio of CaO to SiO_2 shall not be less than 2.0. The magnesium oxide content (MgO) shall not exceed 5.0% by mass.

- As per the availability we have used Ordinary Portland Cement(OPC).
- Cement used is 43 grade cement from Ultratech.
- Specific gravity of cement was 2.89

4.1.3 Fibres

Acrylic Fibre:

Acrylic fibres such as those used in the textile industry have tensile strengths typically in the range of 200–400 MPa. They contain at least 85% by weight of acrylonitrile units. They can form a strong bond with the cement matrix. However, since they have been found to lose strength in the highly alkaline cement environment they are not suitable for use in FRC. More recently, however, high tensile strength acrylic fibres with tensile strengths up to 1000 MPa have been developed, which are being used in FRC.

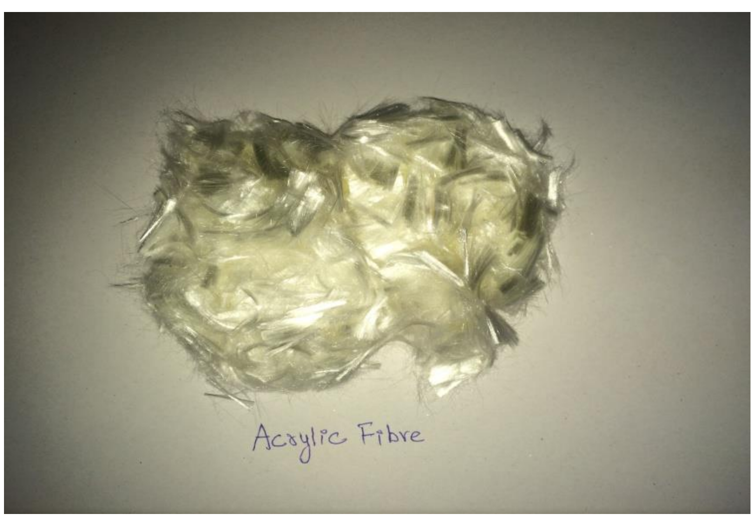

FIGURE 10

Carbon-Nano Fibre:

Carbon nanofibers (CNFs), vapor grown carbon fibres (VGCFs), or vapour grown carbon nanofibers (VGCNFs) are cylindrical nanostructures with graphene layers arranged as stacked cones, cups or plates. Carbon nanofibers with graphene layers wrapped into perfect cylinders are called carbon nanotubes.

Catalytic chemical vapour deposition (CCVD) or simply CVD with variants like thermal and plasma-assisted is the dominant commercial technique for the fabrication of VGCF and VGCNF. Here, gas-phase molecules are decomposed at high temperatures and carbon is deposited in the presence of a transition metal catalyst on a substrate where subsequent growth of the fibre around the catalyst particles is realized. In general, this process involves separate stages such as gas decomposition, carbon deposition, fibre growth, fibre thickening, graphitization, and purification and results in hollow fibres. The nanofiber diameter depends on the catalyst size. The CVD process for the fabrication of VGCF generally falls into two categories: 1) fixed-catalyst process (batch), and 2) floating-catalyst process (continuous).

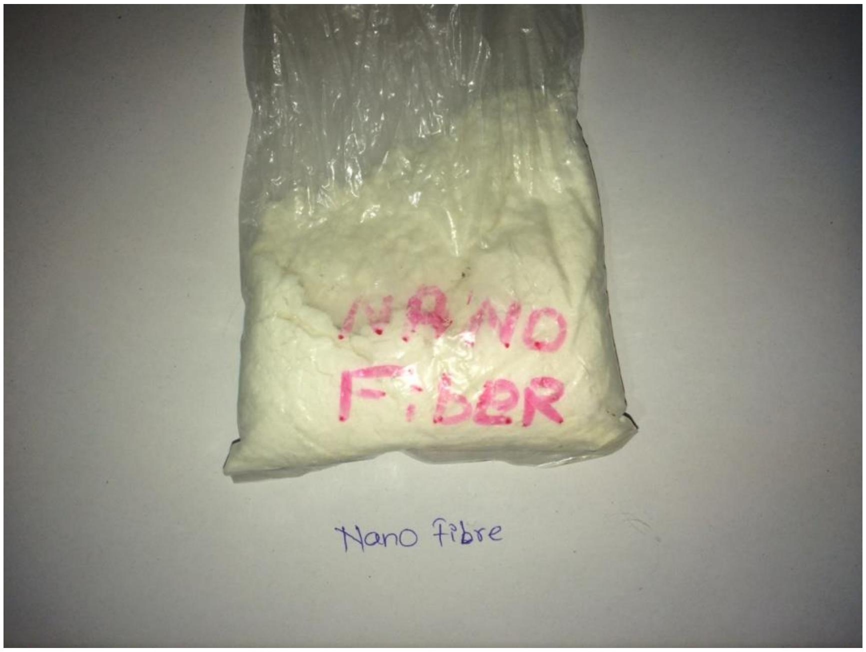

FIGURE 11

4.1.4M-25 Concrete

Fck	Ft	w/c	Min. cement (kg)	Adjustment 1(10mm aggregate)	Water content	Adjustment 2 (sub angular aggregate)	Cement Content (kg)	Zone Of Agg.
25	31.6	0.48	240	280	186	176	367	IV

All values are per m^3 concrete

% of coarse Aggregate	Aggregate vol.	Fine aggregate (weight)	Coarse Aggregate (weight)
0.66	0.6877	620	1203

TABLE 2 MIX DESIGN

- Specific gravity of cement =3.15
- Nominal Max. aggregate size = 20mm
- Exposure condition = moderate
- Specific gravity of coarse aggregate & fine aggregate = 2.65
- **Code used: IS.10262.2009 for mix designing of concrete.**

4.2 Experimental Investigation

4.2.1 Details of specimens

For all tests in this study we have use M25 concrete of standard mix proportion. It is intended to find experimentally the effect of addition of fibers on the properties of concrete to be used for construction purpose. Hence the investigations are taken up to evaluate workability, flexural strength and split tensile strength of plain and fiber reinforced concrete specimens as per standards.

4.2.2 Casting and curing of specimens

The constituent materials of concrete, viz., Cement, Sand and aggregates were tested as per the relevant Indian codes. Concrete of M25 grade was designed. Concrete was mixed in a tilting type drum mixer and the specimens were cast as per the recommendations of IS: 516 - 1959. Standard steel moulds were used for casting of beams of size 500 mm x 100 mm x 100 mm and casting of cylinders of 100 mm diameter and 200 mm height Concrete was placed uniformly over the length of the mould in three layers and compacted satisfactorily. After compacting the entire concrete, the excess concrete at the top of the mould was stuck off with a wooden straight edge and the top finished by a trowel. Demoulding was done after 24 hours and the specimens were cured under water. After 7days and 28days, the cube specimens were removed from curing tank and taken for testing. After 28days, the cylinder specimens were removed from tank and taken for testing.

4.3 Carrying of Flexural and Split Tensile Tests

1. Collection of aggregates, sand, cement in correct proportionate as per the mix design of M-25 concrete.

2. Weighing of Fibre

3. Preparing the moulds (cylindrical and beam) by tightening and oiling them.

   (a) Cylindrical mould- 100x200mm

   (b) Beam mould- 100x100x500mm

4. Mixing of material carried with the help of Concrete Mixer for the time span of 3.5 minutes.

5. Filling of prepared concrete in moulds and compacting them using tampering rod of 16mm diameter with bullet face one end.

6. Opening of the moulds on the next day of casting.

7. Curing of samples for 7 and 28 days.

   (a) For 7 days sample were placed in normal curing tank.

   (b) For 28 days sample were placed in accelerated curing tank for 3 days at the temperature of 90ºC.

8. Testing of samples were conducted;

   (a) Beam samples were tested with the help of UTM for Flexural Strength.

   (b) Cylindrical samples were tested with the help of Compression Testing Machine for Split Tensile Test.

CHAPTER 5: OBSERVATIONS AND RESULT

5.1 Flexural Strength Observations and Result

Flexural Test On Beam (7days)				
	Sample No.	Max. Load(kN)	Strength(Mpa)	Average
M-25 Concrete	1	13.5	5.4	5.5
	2	14.6	5.6	
Acrylic 0.25%	1	14.7	5.9	5.93
	2	14.9	5.96	
Acrylic 0.5%	1	15	6	6.05
	2	15.2	6.1	
Acrylic 1.0%	1	15.5	6.2	6.2
	2	15.5	6.2	
Acrylic 1.25%	1	15.8	6.3	6.35
	2	16.1	6.4	
Carbon Nano 0.25%	1	16.5	6.6	6.7
	2	17.1	6.8	
Carbon Nano 0.5%	1	17.5	7	7.05
	2	17.8	7.1	
Carbon Nano 1%	1	17	6.8	6.75
	2	16.8	6.7	
Carbon Nano 1.25%	1	18.4	7.36	7.38
	2	18.5	7.4	

TABLE 3 FLEXURAL TEST (7 DAYS)

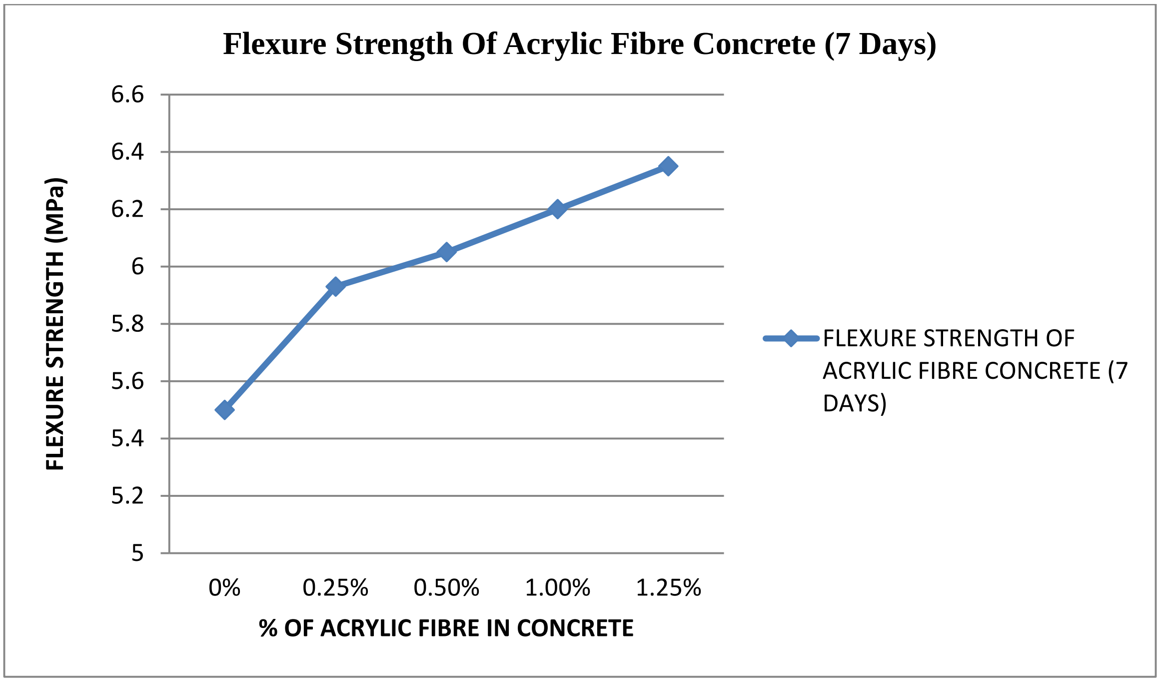

FIGURE 12: FLEXURE STRENGTH OF ACRYLIC FIBRE CONCRETE (7 DAYS)

Flexure Strength Of Acrylic Fibre Concrete (7 Days)	
% of Acrylic Fibre	**Strength**
0%	5.5
0.25%	5.93
0.50%	6.05
1.00%	6.2
1.25%	6.35

TABLE 4: FLEXURE STRENGTH OF ACRYLIC FIBRE CONCRETE (7 DAYS)

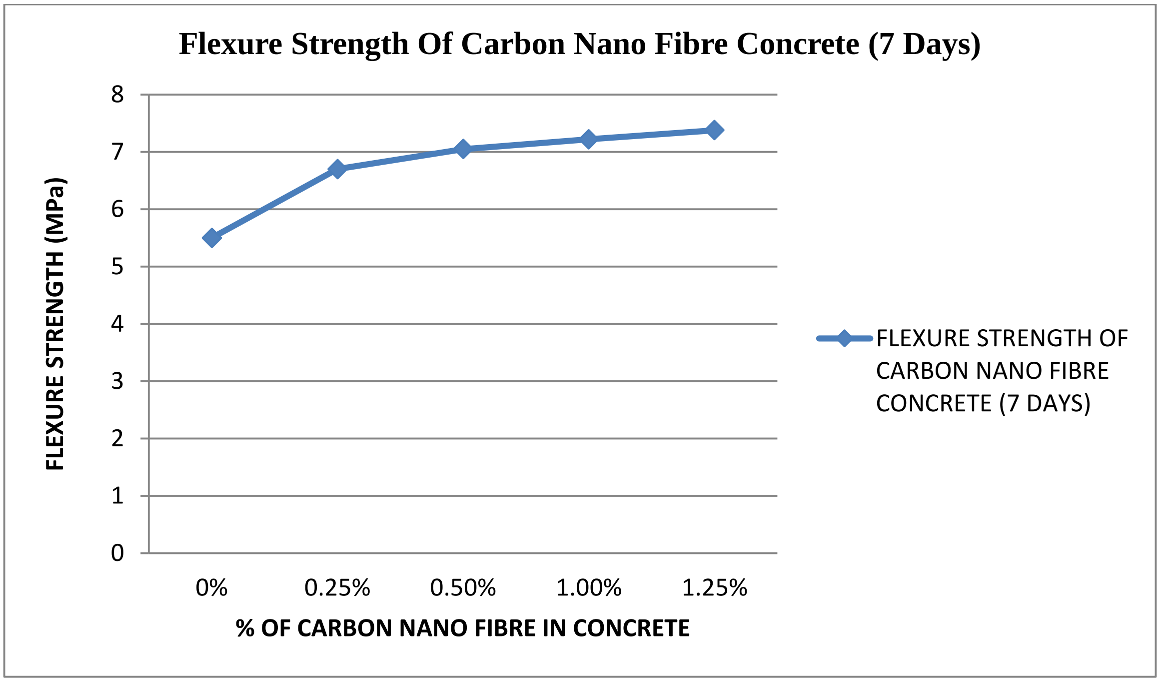

FIGURE 13: FLEXURE STRENGTH OF CARBON NANO FIBRE CONCRETE (7 DAYS)

Flexure Strength Of Carbon Nano Fibre Concrete(7 Days)	
% Of Carbon Nano Fibre	**Strength**
0%	5.5
0.25%	6.7
0.50%	7.05
1.00%	7.22
1.25%	7.38

TABLE 5:FLEXURE STRENGTH OF CARBON NANO FIBRE CONCRETE (7 DAYS)

Flexural Test On Beam (28days)				
	Sample No.	Max. Load(kN)	Strength(Mpa)	Average
M-25 Concrete	1	14.7	5.9	5.75
	2	14	5.6	
Acrylic 0.25%	1	14.3	5.72	5.86
	2	15	6	
Acrylic 0.5%	1	15.8	6.3	6.35
	2	16	6.4	
Acrylic 1.0%	1	16	6.4	6.45
	2	16.3	6.5	
Acrylic 1.25%	1	19	7.6	7.82
	2	20.1	8.04	
Carbon Nano 0.25%	1	16	6.4	6.58
	2	16.9	6.76	
Carbon Nano 0.5%	1	18.5	7.4	6.95
	2	18.5	7.4	
Carbon Nano 1%	1	19.8	7.9	7.85
	2	19.5	7.8	
Carbon Nano 1.25%	1	23	9.2	9.04
	2	22.2	8.88	

TABLE 6: FLEXURAL TEST (28 DAYS)

$$F=Pl/bd^2$$

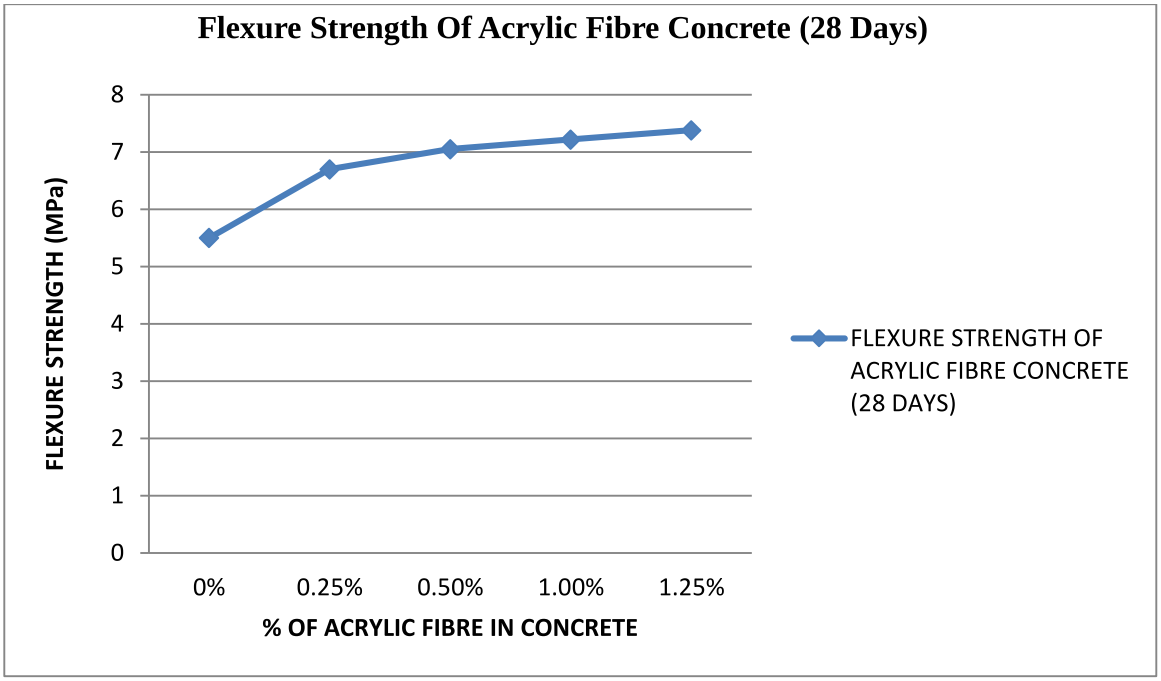

FIGURE 14:FLEXURE STRENGTH OF ACRYLIC FIBRE CONCRETE (28 DAYS)

Flexure Strength Of Acrylic Fibre Concrete (28 Days)	
% of Acrylic Fibre	**Strength**
0%	5.5
0.25%	6.7
0.50%	7.05
1.00%	7.22
1.25%	7.38

TABLE 7: FLEXURE STRENGTH OF ACRYLIC FIBRE CONCRETE (28 DAYS)

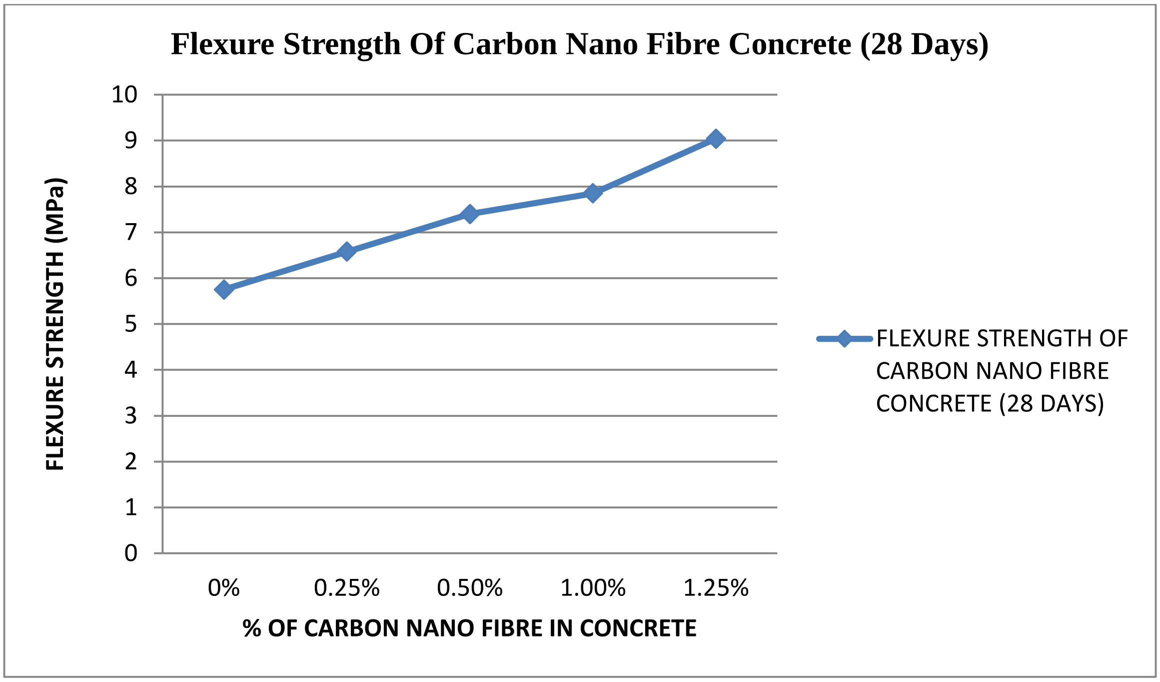

FIGURE 15: FLEXURE STRENGTH OF CARBON NANO FIBRE CONCRETE (28 DAYS)

Flexure Strength Of Carbon Nano Fibre Concrete (28 Days)	
% of Carbon Nano Fibre	**Strength**
0%	5.75
0.25%	6.58
0.50%	7.4
1.00%	7.85
1.25%	9.04

TABLE 8: FLEXURE STRENGTH OF CARBON NANO FIBRE CONCRETE (28 DAYS)

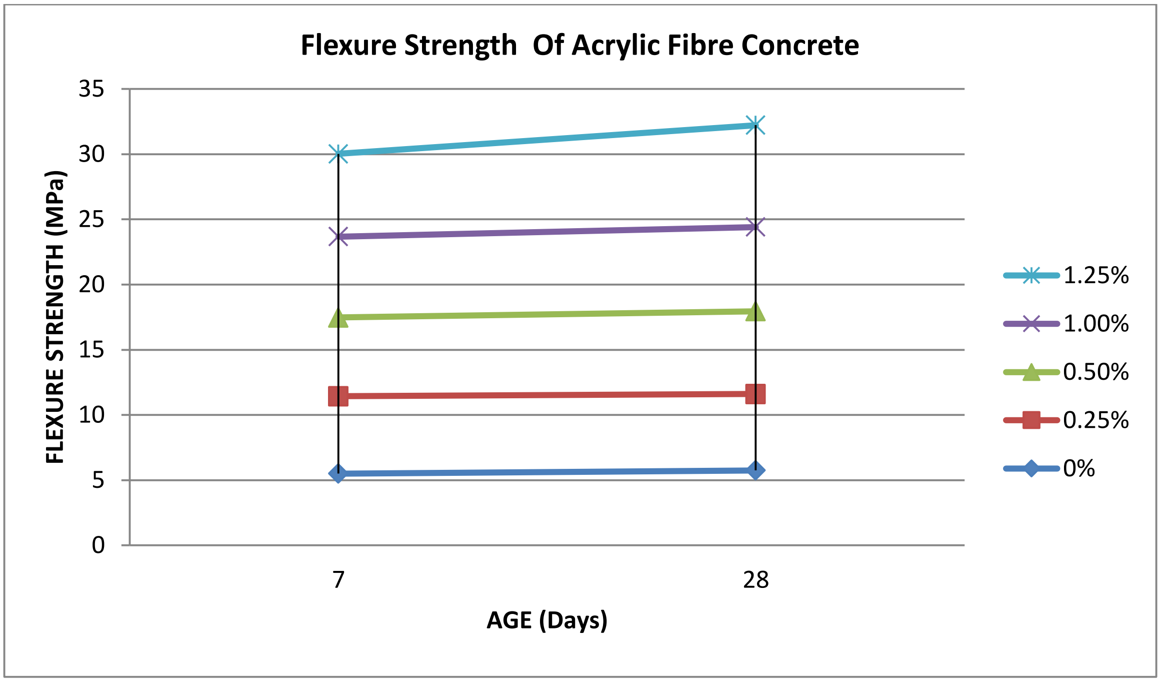

FIGURE 16: CHANGE IN FLEXURAL STRENGTH WITH RESPECT TO DAYS

Flexural Strength Of Acrylic Fibre Concrete					
Days	% of Acrylic Fibre by volume				
	0%	0.25%	0.50%	1.00%	1.25%
7	5.5	5.93	6.05	6.2	6.35
28	5.75	5.86	6.35	6.45	7.82

TABLE 9: : CHANGE IN FLEXURAL STRENGTH WITH

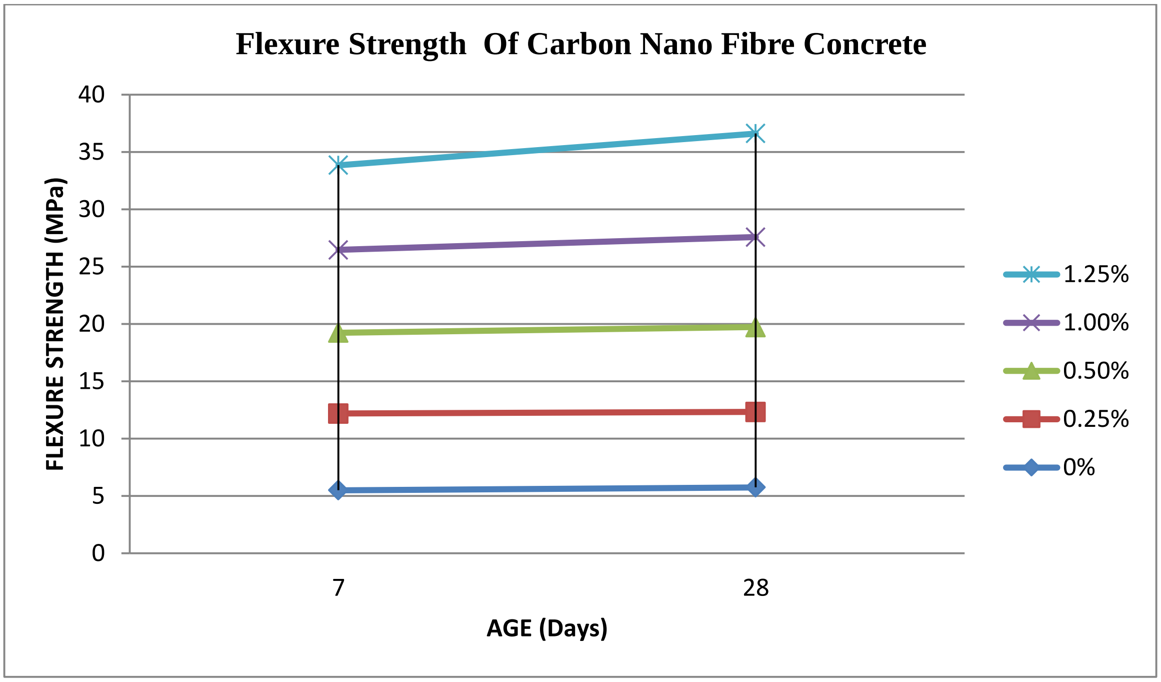

FIGURE 17: CHANGE IN FLEXURAL STRENGTH WITH RESPECT TO DAYS

Flexural Strength Of Carbon Nano Fibre Concrete					
Days	% of Carbon Nano Fibre by volume				
	0%	0.25%	0.50%	1.00%	1.25%
7	5.5	6.7	7.05	7.22	7.38
28	5.75	6.58	7.4	7.85	9.04

TABLE 10 FLEXURAL STRENGTH OF CARBON NANO FIBRE CONCRETE

5.2 Split Tensile Strength Observations and Results

Split Tensile Test On Cylinders (7days)				
	Sample No.	Max. Load(kN)	Strength(Mpa)	Average
M-25 Concrete	1	70	2.2	2.05
	2	60	1.9	
Acrylic 0.25%	1	65	2.1	2.15
	2	70	2.2	
Acrylic 0.5%	1	65	2.1	2.25
	2	75	2.4	
Acrylic 1.0%	1	80	2.5	2.6
	2	85	2.7	
Acrylic 1.25%	1	95	3	2.95
	2	90	2.9	
Carbon Nano 0.25%	1	95	3	3.1
	2	100	3.2	
Carbon Nano 0.5%	1	100	3.2	3.25
	2	105	3.3	
Carbon Nano 1%	1	130	4.1	4.1
	2	130	4.1	
Carbon Nano 1.25%	1	135	4.3	4.4
	2	140	4.5	

TABLE 11: SPLIT TENSILE TEST ON CYLINDERS (7DAYS)

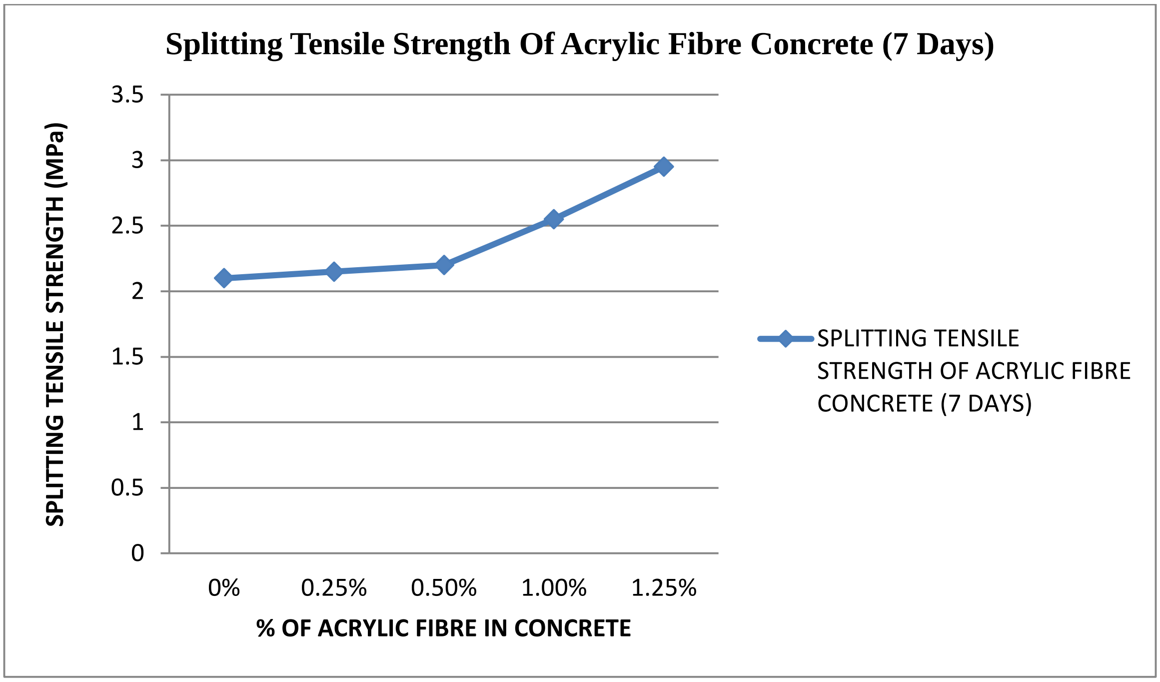

FIGURE 18: SPLITTING TENSILE STRENGTH OF ACRYLIC FIBRE CONCRETE (7 DAYS)

Splitting Tensile Strength Of Acrylic Fibre Concrete (7 Days)	
% Of Acrylic Fibre	**Strength**
0%	2.1
0.25%	2.15
0.50%	2.2
1.00%	2.55
1.25%	2.95

TABLE 12: SPLITTING TENSILE STRENGTH OF ACRYLIC FIBRE CONCRETE (7 DAYS)

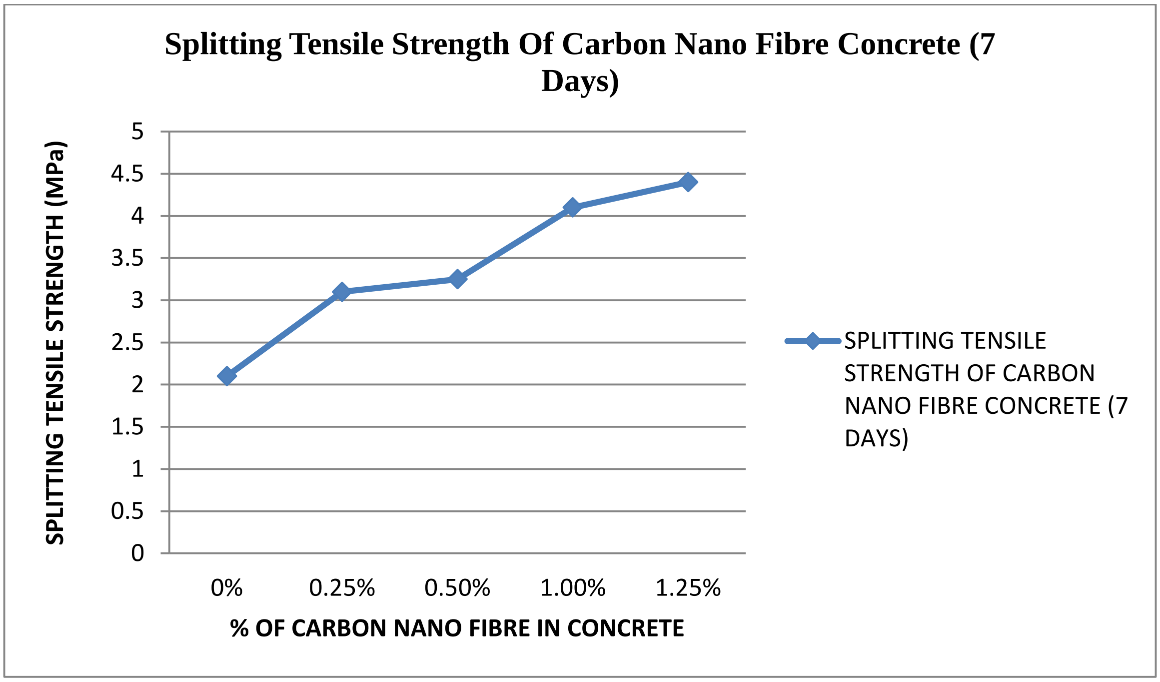

FIGURE 19: SPLITTING TENSILE STRENGTH OF CARBON NANO FIBRE CONCRETE (7 DAYS)

Splitting Tensile Strength Of Carbon Nano Fibre Concrete (7 Days)	
% Of Carbon Nano Fibre	**Strength**
0%	2.1
0.25%	3.1
0.50%	3.25
1.00%	4.1
1.25%	4.4

TABLE 13: SPLITTING TENSILE STRENGTH OF CARBON NANO FIBRE CONCRETE (7 DAYS)

Split Tensile Test on Cylinders (28days)				
	Sample No.	Max. Load(kN)	Strength(Mpa)	Average
M-25 Concrete	1	106	3.4	3.25
	2	95	3.1	
Acrylic 0.25%	1	100	3.2	3.3
	2	106	3.4	
Acrylic 0.5%	1	100	3.2	3.25
	2	104	3.3	
Acrylic 1.0%	1	113	3.6	3.55
	2	110	3.5	
Acrylic 1.25%	1	120	3.82	4.01
	2	130	4.2	
Carbon Nano 0.25%	1	115	3.7	3.85
	2	125	4	
Carbon Nano 0.5%	1	119	3.8	3.9
	2	125	4	
Carbon Nano 1%	1	142	4.5	4.5
	2	135	4.3	
Carbon Nano 1.25%	1	140	4.45	4.53
	2	145	4.6	

TABLE 14:SPLIT TENSILE TEST ON CYLINDERS (28DAYS)

Fsp = 2P/∏dl = 0.637 P/dl

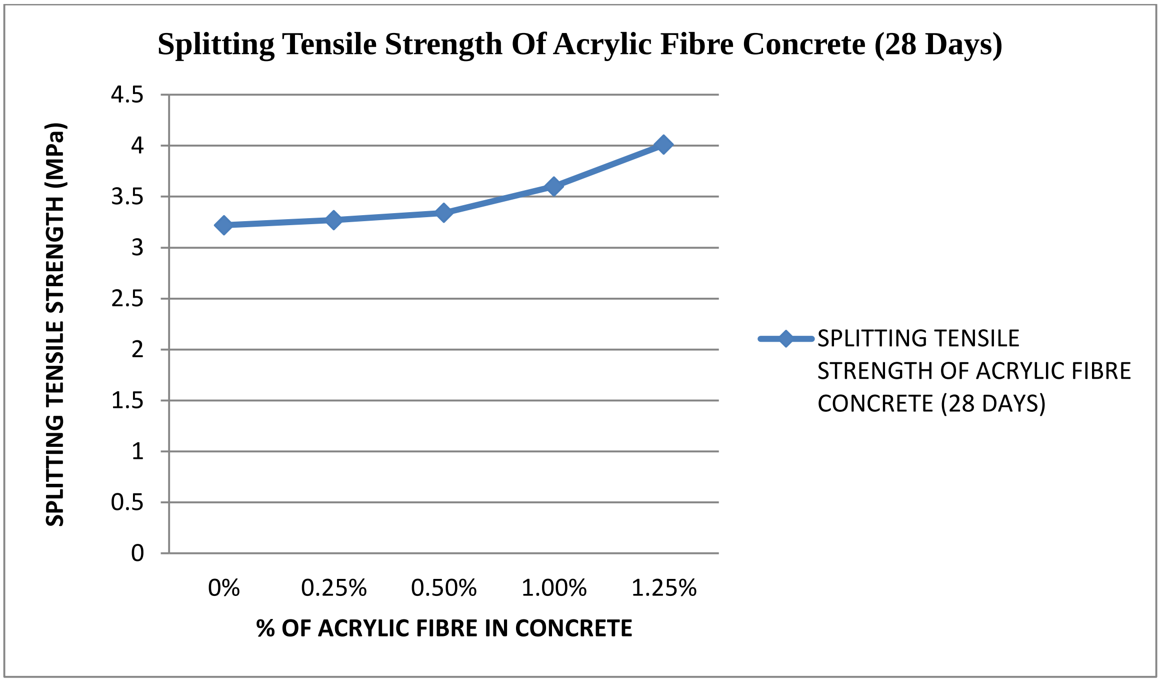

FIGURE 20:SPLITTING TENSILE STRENGTH OF ACRYLIC FIBRE CONCRETE (28 DAYS)

Splitting Tensile Strength Of Acrylic Fibre Concrete (28 Days)	
% of Acrylic Fibre	**Strength**
0%	3.22
0.25%	3.27
0.50%	3.34
1.00%	3.6
1.25%	4.01

TABLE 15: SPLITTING TENSILE STRENGTH OF ACRYLIC FIBRE CONCRETE (28 DAYS)

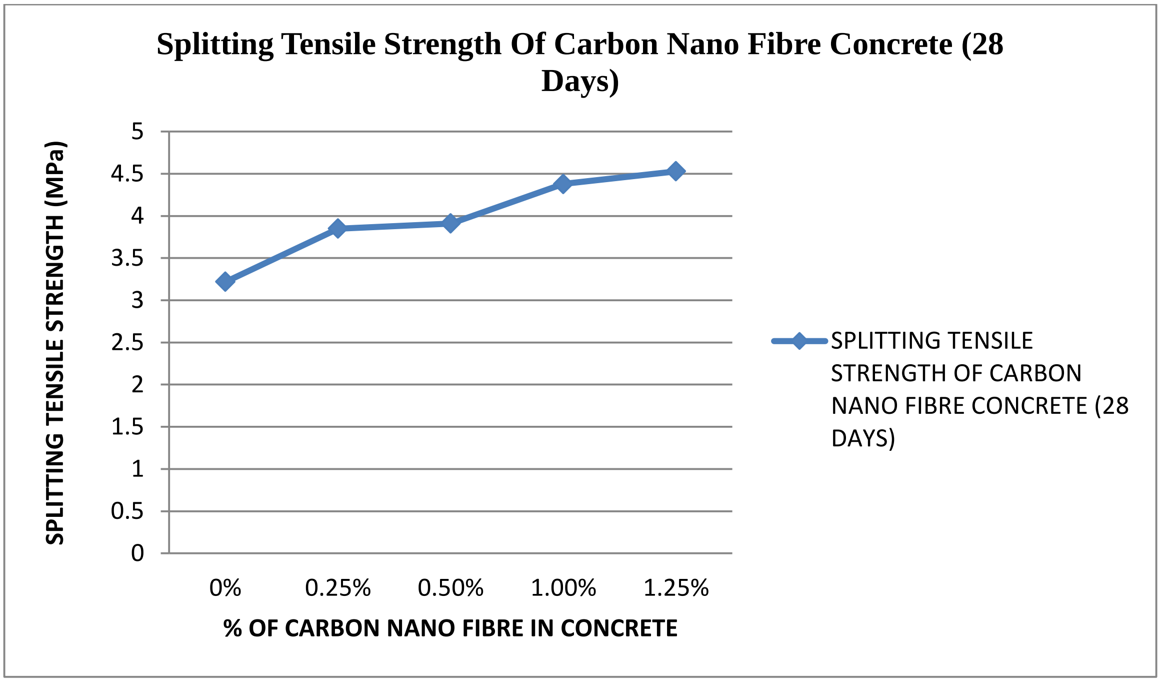

FIGURE 21: SPLITTING TENSILE STRENGTH OF CARBON NANO FIBRE CONCRETE (28 DAYS)

Splitting Tensile Strength Of Carbon Nano Fibre Concrete (28 Days)	
% of Carbon Nano Fibre	**Strength**
0%	3.22
0.25%	3.85
0.50%	3.91
1.00%	4.38
1.25%	4.53

TABLE 16: SPLITTING TENSILE STRENGTH OF CARBON NANO FIBRE CONCRETE (28 DAYS)

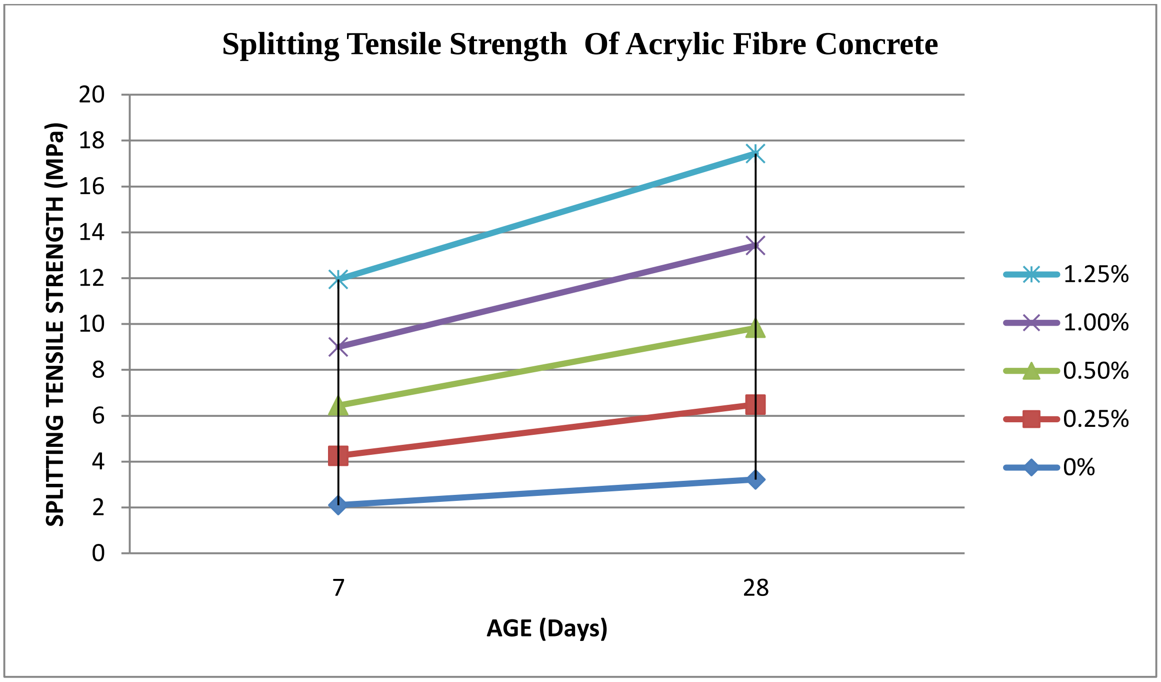

FIGURE 22: CHANGE IN SPLITTING TENSILE STRENGTH WITH RESPECT TO DAYS

Splitting Tensile Strength Of Acrylic Fibre Concrete					
Days	% of Acrylic Fibre by volume				
	0%	0.25%	0.50%	1.00%	1.25%
7	2.1	2.15	2.2	2.55	2.95
28	3.22	3.27	3.34	3.6	4.01

TABLE 17: CHANGE IN SPLITTING TENSILE STRENGTH WITH RESPECT TO DAYS

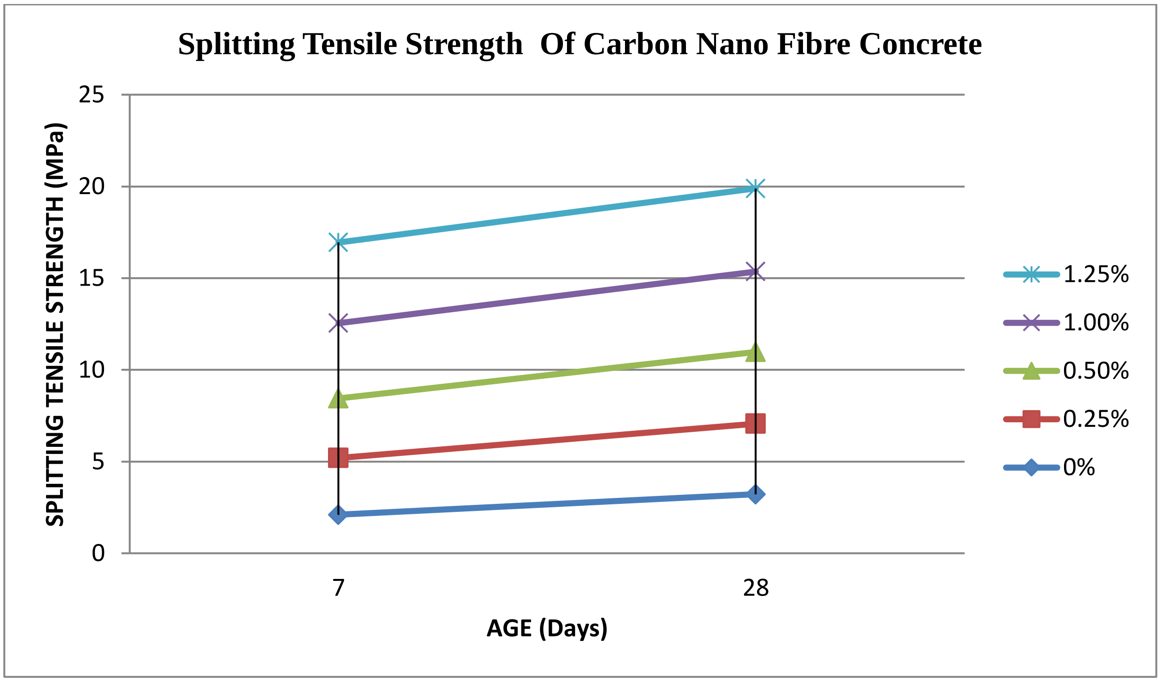

FIGURE 23: CHANGE IN SPLITTING TENSILE STRENGTH WITH RESPECT TO DAYS

Splitting Tensile Strength Of Carbon Nano Concrete					
Days	% of Carbon Nano Fibre				
	0%	0.25%	0.50%	1.00%	1.25%
7	2.1	3.1	3.25	4.1	4.4

TABLE 18: CHANGE IN SPLITTING TENSILE STRENGTH WITH RESPECT TO DAYS

CHAPTER 6: CONCLUSION & DISCUSSION

6.1 Conclusion

6.1.1 Effect on Flexural Strength with fibres

- The flexural strength of **normal M-25** concrete in duration of 28 days observed from our testing comes out to be **5.75 MPa**.
- The flexural strength of M-25 concrete with addition of **0.25%, 0.5%, 1.0%**and **1.25% acrylic fibre**(by vol. fraction of concrete) at the end of **28 days** observed is **5.86 MPa, 6.35 MPa, 6.45 MPa** and **7.82 MPa** respectively.
- Increase in flexural strength with addition of **0.25%, 0.5%, 1.0% and 1.25%acrylicfibre** at **28 days** span is **1.91%, 10.43%, 12.17%**and **36%** respectively.
- The flexural strength of M-25 concrete with addition of **0.25%, 0.5%, 1.0%** and **1.25% carbon nanofibre**(by vol. fraction of concrete) at the end of **28 days** observed is **6.58 MPa, 7.4 MPa, 7.85 MPa** and **9.04 MPa** respectively.
- Increase in flexural strength with addition of **0.25%, 0.5%, 1.0%** and **1.25% nanofibre** at **28 days** span is **14.43%, 28.69%, 36.52%** and **57.22%** respectively.,

6.1.2 Effect on Splitting Tensile Strength with fibres

- The splitting tensile strength of **normal M-25** concrete in duration of 28 days observed from our testing comes out to be **3.22 MPa.**.
- The splitting tensile strength of M-25 concrete with addition of **0.25%, 0.5%, 1.0% and 1.25% acrylic fibre**(by vol. fraction of concrete) at the end of **28 days** observed is **3.27 MPa, 3.34 MPa, 3.6 MPa** and **4.01 MPa** respectively.
- Increase in splitting tensile strength with addition **of 0.25%, 0.5%, 1.0% and 1.25% acrylic fibre** at **28 days** span is **1.55%, 3.73%, 11.80%** and **24.53%** respectively.

- The splitting tensile strength of M-25 concrete with addition of **0.25%, 0.5%. 1.0% and 1.25% carbon nanofibre**(by vol. fraction of concrete) at the end of **28 days** observed is **3.85 MPa, 3.91 MPa, 4.38 MPa** and **4.53 MPa** respectively.
- Increase in splitting tensile strength with addition of **0.25%, 0.5%, 1.0% and 1.25% nanofibre** at **28 days** span is **19.56%, 21.43%, 36.02%** and **40.68%** respectively.

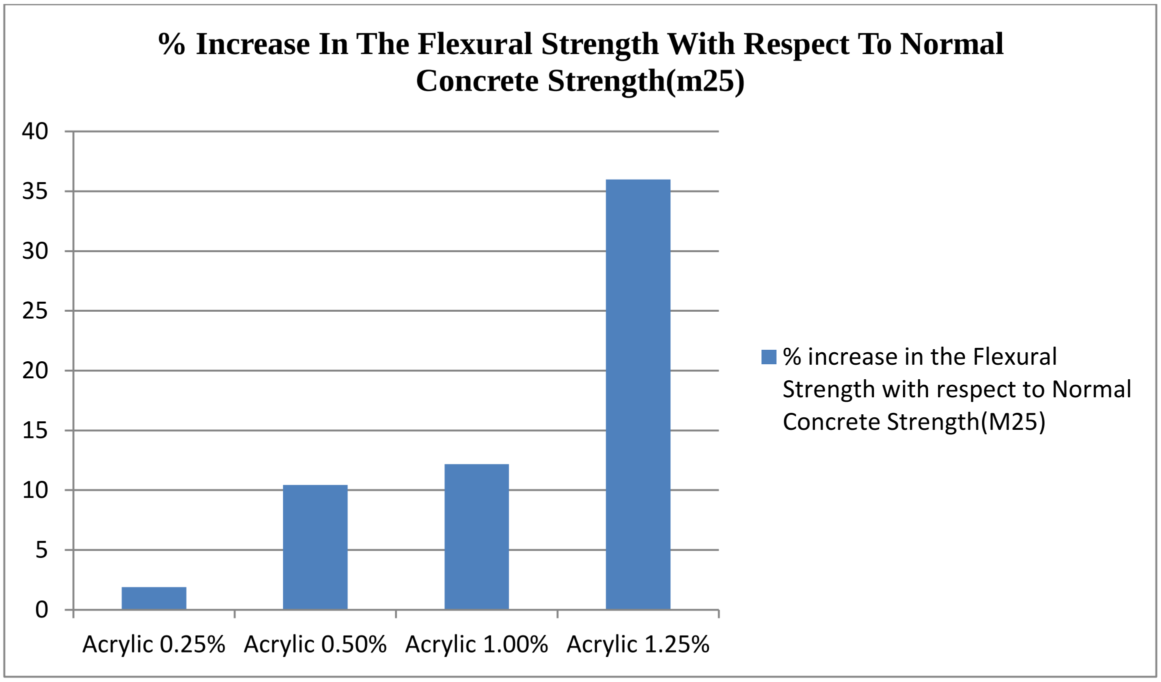

FIGURE 24: % INCREASE IN THE FLEXURAL STRENGTH WITH ACRYLIC FIBRE

% Increase In The Flexural Strength With Respect To Normal Concrete Strength(M25)		
% of fibre	7 Days	28 Days
Acrylic 0.25%	7.81	1.91
Acrylic 0.50%	10	10.43
Acrylic 1.00%	12.72	12.17
Acrylic 1.25%	15.45	36

TABLE 19: % INCREASE IN THE FLEXURAL STRENGTH WITH ACRYLIC FIBRE

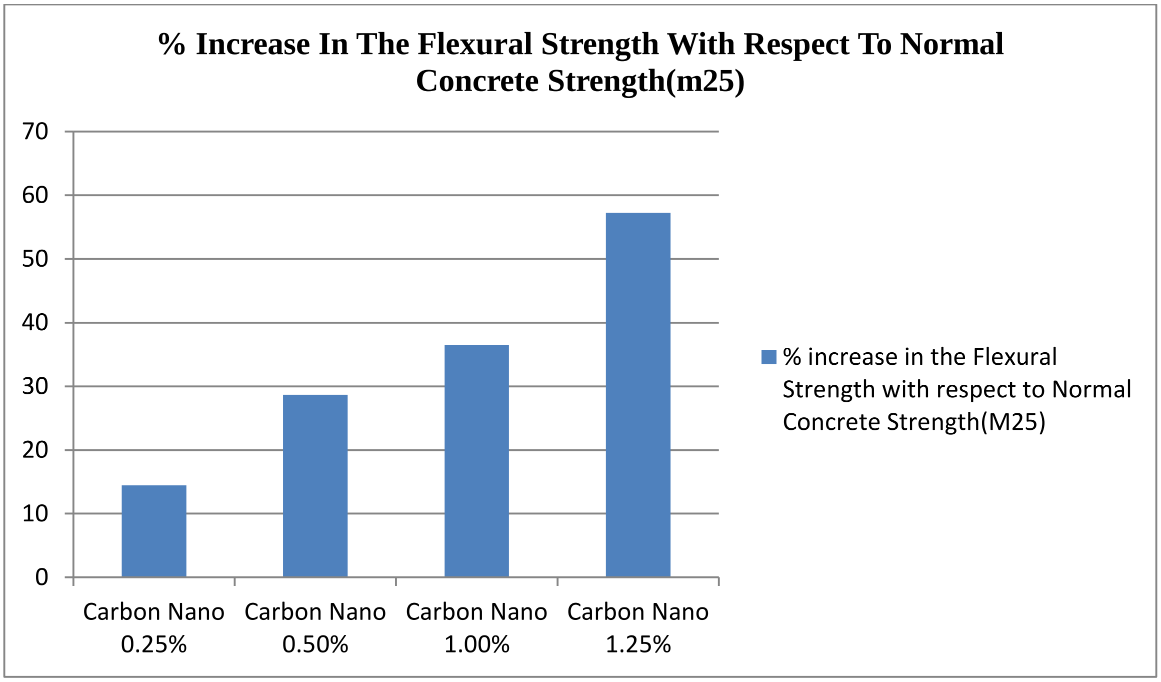

FIGURE 25: % INCREASE IN THE FLEXURAL STRENGTH WITH CARBON NANO FIBRE

% Increase In The Flexural Strength With Respect To Normal Concrete Strength(M25)		
% of Fibre	7 Days	28 Days
Carbon Nano 0.25%	21.82	14.43
Carbon Nano 0.50%	28.18	28.69
Carbon Nano 1.00%	31.27	36.52
Carbon Nano 1.25%	34.18	57.22

TABLE 20: % INCREASE IN THE FLEXURAL STRENGTH WITH CARBON NANO FIBRE

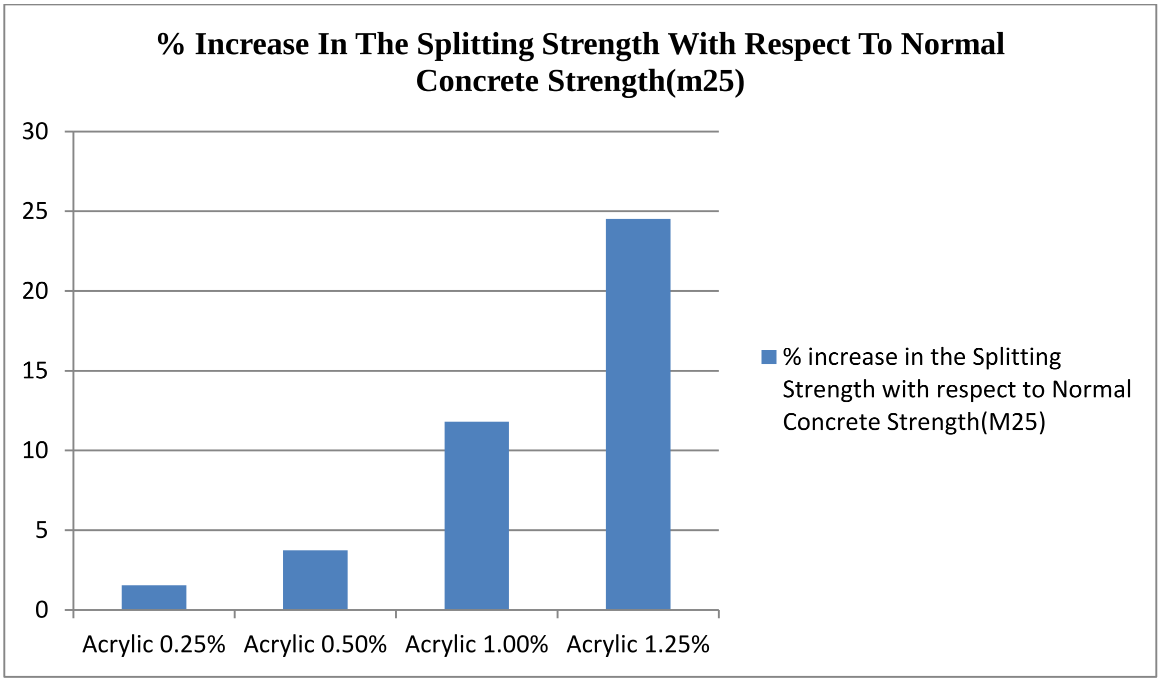

FIGURE 26: % INCREASE IN THE SPLITTING STRENGTH WITH ACRYLIC FIBRE

% Increase In The Splitting Tensile Strength With Respect To Normal Concrete Strength(M25)		
% of Fibre	7 Days	28 Days
Acrylic 0.25%	2.32	1.55
Acrylic 0.50%	4.76	3.73
Acrylic 1.00%	21.43	11.8
Acrylic 1.25%	40.48	24.53

TABLE 21: % INCREASE IN THE SPLITTING STRENGTH WITH ACRYLIC FIBRE

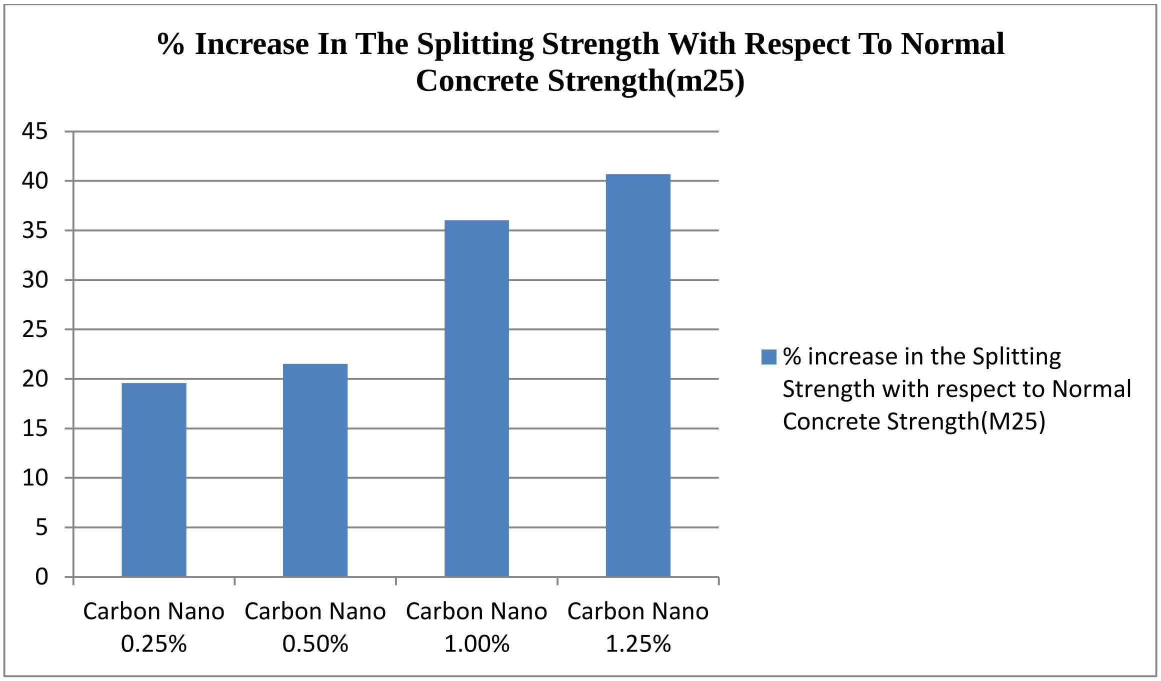

FIGURE 27: % INCREASE IN THE SPLITTING STRENGTH WITH CARBON NANO FIBRE

% Increase In The Splitting Strength With Respect To Normal Concrete Strength(M25)		
% of Fibre	7 Days	28 Days
Carbon Nano 0.25%	46.62	19.56
Carbon Nano 0.5%	54.76	21.43
Carbon Nano 1.0%	95.24	36.02
Carbon Nano 1.25%	109.52	40.68

TABLE 22: % INCREASE IN THE SPLITTING STRENGTH WITH CARBON NANO FIBRE

6.2 Discussion

- The reason for the increase in flexural strength and splitting tensile strength is due to the addition of respective fibres in various percentages.
- The fibres increases the capability of concrete to resist more stress and strain which directly increases its flexural and splitting tensile strength.
- These test result observed proves that the dispersion of fibres in the concrete was perfect.

CHAPTER 7: SCOPE IN THE FUTURE

- We have used 0.25%, 0.5%, 1.0% and 1.25% (by vol. of concrete) content of acrylic and carbon nanofibres , to check its effect on the flexure and splitting tensile strength which showed the increase in strength.
- Further in future we can increase the percentage of fibres to check whether there is increase or decrease in flexure strength or splitting tensile strength.
- We can also add our acrylic and carbon nanofibre together in different proportions to check the combined effect of acrylic and carbon nanofibre on the flexure and splitting tensile strength

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