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EXPERIMENTAL STUDY ON THE PERFORMANCE OF CONCRETE USING VARIOUS TYPES OF FIBERS LIKE POLYPROPYLENE, POLYETHYLENE AND NYLON

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Chapter I

1. Synopsis:

All over the world concrete plays an important role in the construction industry. There are some boundaries on the use of concrete as a binding material for certain deficiencies such as low durability, low ductility, fatigue, brittleness and poor resistance, and poor tensile strength on impact strength. In this current situation waste materials collected from various industries are added to the concrete mix with admixture. Fiber-reinforced concrete (FRC) has been widely used as a non-corrosive material as well as high strength and lightweight materials. Fiber reinforced concrete helps to improve structural strengthening both economically and efficiently. In terms of bearing capacity, ductility, and durability, fiber reinforced concrete helps to create an exciting structure for prominent improvement. In steel-reinforced concrete corrosion may be unsafe for structure. FRC helps to decrease the permeability of concrete by using glass, steel, and polymer fibers. As a result of using steel, FRC helps to improve yield strength, glass fiber helps to increase flexural strength and polymer fiber increases high corrosion resistance but reduces fire resistance capacity. Fiber-reinforced concrete can be used as economical cementitious material which also helps in sustainable construction. In this research paper, researchers will conduct a test on 6 M25 grade concrete mix and will do a compression test, tensile test, and flexural test. After that, the result of fiber-reinforced concrete will be compared with traditional structures. This research paper significantly focuses on nylon fiber, polypropylene fiber and polyethylene fiber.

Keywords: *Concrete, Fiber-reinforced concrete, Polypropylene fiber, Polyethylene fiber, M25, OPC 53, CA, FA, Nylon fiber, Modern concrete*

2. Objective of Research Work:

Fiber-reinforced concrete helps to increase concrete strength at low cost in addition it also provides tensile reinforcement of the structure in all directions. FRC also helps to reduce the requirement of steel reinforcement.

- To improve the strength of the structure.
- To reduce the requirements of steel structure.
- To improve impact, abrasion, and resistance.
- To improve ductility and reduce crack.
- To minimise the damage to the structure.
- The Compressive and flexural power of fiber reinforced Concrete for 7, 14 and 28 days is discovered out and as compared with traditional concrete of similar mix design.
- It will be easy to use and it also increases compressive and flexural strength.

Chapter II

1. Introduction:

Concrete is widely known as a versatile and cost-effective construction material but concrete also has a huge no. of drawbacks in inherent composition. For any country's infrastructure development concrete is a primary element. Besides all properties in concrete, compressive strength is considered a useful quality. Though for a long time concrete performance changed into durability. For any concrete mixture, durability shows a significant amount without any substantial damage. Fiber reinforcement is one of the best methods to ensure durable structure for a long time. Concrete materials with fly ash and silica fume reduce permeability. This problem only occurs when the concrete is in the curing stage. Various types of fiber-reinforced concrete are used all over the world. On fiber reinforced versatile performance, many studies are already done.

Nylon is an easily available material that can be used in fiber reinforced concrete as a “Nylon fiber”. Nylon is a material that helps to resist chemical attack in concrete and provide high abrasion resistance in concrete. Nylon is also considered a nonreactive material. Jute fiber is also considered natural fiber. An increase of fiber materials in concrete helps to improve chemical properties in the concrete. Concrete cannot bear cracks and tension which occurs in tensile areas. In this tension area fiber such as nylon, PPF, PEF steel, and other fiber materials can be used to prevent cracks in that particular tension zone.

2. Literature Review

Concrete is a primary material for the construction industry. Due to infrastructure development in the developing countries, consumption of concrete is very high. The consumption of cement is also very high to meet the requirements. So there is a need to look after the substitute materials for the cement, fine aggregate and coarse aggregate. The current work aims to look an alternative material of concrete.

Fiber Reinforced Concrete can be defined as a composite material consisting of mixtures of cement, mortar, or concrete and discontinuous, discrete, uniformly dispersed suitable fibers. Fiber-reinforced concrete is of different types and properties with many advantages. Continuous meshes, woven fabrics, and long wires or rods are not considered to be discrete fibers. Fiber is a small piece of reinforcing material possessing certain characteristic properties. They can be circular or flat. The fiber is often described by a convenient parameter called "aspect ratio". The aspect ratio of the fiber is the ratio of its 9 length to its diameter. The typical aspect ratio ranges from 30 to 150. Fiber Reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers, synthetic fibers, and natural fibers. Within these different fibers, the character of fiber reinforced concrete changes with varying concrete, fiber materials, geometries, distribution, orientation, and densities. Fiber Reinforcement is mainly used in shotcrete, but can also be used in normal concrete.

Fiber-reinforced normal concrete is mostly used for on-ground floors and pavements, but can be considered for a wide range of construction parts (beams, pliers, foundations, etc.) either alone or with hand-timed rebars Concrete reinforced with fibers (which are usually steel, glass, or "plastic" fibers) is less expensive than hand-timed rebar, while still increasing the tensile strength many times. The shape, dimension, and length of fiber are important. A thin and short fiber, for example, short hair-shaped glass fiber, will only be effective the first hours after pouring the concrete (reduces cracking while the concrete is stiffening) but will not increase the concrete tensile strength.

A search of the literature found that numerous laboratory studies on either fly ash/lime stabilisation of soil or fibre reinforced soil have been carried out independently. In recent years, studies on the use of lime and fly ash for stabilising soil have been done. By numerous researchers including Mitchell and Katti (1981), Maher et al (1993), and Consoli et al (2001). The Lime reactions involve both short-term and long-term physical and chemical mechanisms. FRC for stabilising load have been extensively discussed in the literature.

When Gray and Ohashi (1983) conducted flexural strength tests on beam specimens, the results showed increased shear strength and ductility as well as decreased post-peak strength loss. Individual fibres. The investigation also revealed that the relationship between shear strength and fibre area is direct. Ratio and fibre length within a specific range.

Numerous researchers supported these findings. Ray and Maher (1986), Gray and Al-Refeai (1986), and others have used compression strength tests (1989), Michaowski and Zhao (1996), and Al-Refeai (1991), Ranjan et al. (1996), Michaowski and Cermak (1996) (2003). Increased kaolinite fibre toughness and strength, according to Maher and Ho (1994). Fibre length and content, as well as water content, were factors in the composite.

It was shown that as fibre length, ductility increased and the contribution of fibres to peak compressive strength decreased. According to Consoli et al. (1998), adding fibreglass to concrete significantly raises peak strength. According to Consoli et al. (2002), adding polyethene fibre to concrete helps enhances peak and ultimate strength, which is based on fibre content. For varying degrees of compaction, Kumar S. and Tabor E. (2003) investigated the strength behaviour of concrete with nylon fibre.

Chakraborty and Dasgupta (1996) used triaxial experiments to investigate the impact of polymer fibre inclusion on concrete. concrete was employed, with a fibre content of 0 to 4 percent by weight and a constant fibre aspect ratio of 30. According to the analysis, the friction angle has increased. Kaniraj and Havanagi (2001) conducted a study on FRC mixture reinforced with 1% polyester fibres (20 mm length), which revealed the combined impact of FRC.

According to Kaniraj and Gayatri (2003), adding 1 per cent polyester fibres (6 mm in length) to control concrete enhanced its strength and transformed its brittle failure into a ductile one. compression tests on concrete block ratio values for flexural test also conducted by Dhariwal, and Ashok, in 2003.

Because of its density and relative higher tensile strength, nylon fibre is a viable reinforcing fiber. Similar to a concrete matrix and free from corrosion possible. Tests on single fiber pull out were conducted, and then the fiber's tensile strength, was calculated by fibre inclination According to the test results, basalt fibre is chemically tightly bound to the cementitious matrix, 1.88 times larger than that of fibres made of polyvinyl alcohol it. Other characteristics of basalt fibre, like slip-Strength-reduction coefficient and hardening coefficient were worse than PE fibres and polyvinyl alcohol in terms of the capacity of fibre bridging (Song et al., 2005). The ductility of concrete greatly improved and the maximum compressive strength was marginally enhanced by adding more polypropylene fibres to the mix.

The ultimate bond strength was not increased by adding more polypropylene fibres (higher values than 0.5 vol. per cent), but the bond behaviour was significantly more ductile. Additionally, the percentage of water absorption for the examined concrete specimens significantly increased as a result of the addition of polypropylene fibres (Mohamed, 2006).

With the addition of Dyneema fibre, the slump value and workability of the concrete decreased. For this purpose, AE water reduction was added to the concrete mix to boost compressive strength while also making it easier to work with. It has been determined that adding 1.5 per cent of fibre to the mixture produced the best favourable results (Chen, 2012).

Marble dust has been used in place of sand in traditional concrete, which was quite effective in boosting strength without degrading the material's characteristics when it was fresh and cured. Sand has been partially replaced with marble dust in the concrete mix. Additions of marble dust were made at percentages of 10, 20, 30, 40, and 50%. PE fibre was incorporated into the concrete in percentages of 0.2%, 0.4%, 0.6%, 0.8%, and 1%. The investigative work's findings indicated that marble dust replacement with PE fibre increased concrete's compressive strength by up to 6% and split tensile strength and flexural strength by up to 8% (Amudhavalli and Thilaga, 2017).

Comparing the fibre-containing concrete to plain concrete, the fibre-containing concrete's tensile strength increased by 39% while the compressive strength suffered a tiny (2%) drop. According to the experimental findings, the likelihood of plastic shrinkage fractures in concrete decreased by 50 to 99 per cent when 0.1 to 0.3 per cent of fibre was added to the mix. Test within for reference concrete (without fibre).

Hasan and others (Polytechnic Journal | 2019 | Vol. 9 | No. 1) and highlight-temperature room produced crack widths that were more than the ACI 224-approved limit of 3 mm. The fracture width was reduced to 1 mm with the addition of 0. Per cent fibre, and the pattern was sustained with the addition of more fibres. Results, however, showed that the addition of the regulated humidity and high-temperature chamber resulted in crack widths that were higher than the permitted limit (3 mm) as defined by ACI 224. There is 0.1 per cent fibre added. Decreased the crack's width to 1 mm, and the pattern was more fibres were added and the process proceeded. However, results showed that adding polypropylene had the desired effect. Fibre’s permeability to both gases and water increased (Sadiqul et al., 2016).

The design and preparation of an ultra-high-performance mortar (UHPM) reinforced by micro steel fibres with a 1.5vol% content as well as a UHPM reinforced by PE fibres with three different fibre contents. To determine how PE fibre affected the UHPM's characteristics, several studies were conducted. The results show that the PE fibre-reinforced UHPM has a lower strength level, a higher tensile strain capacity, toughness, and a larger crack width than the micro steel fibre-reinforced UHPM. Additionally, it was shown that the proposed PE-fibre-reinforced UHPM could be used to achieve tensile strain capacity and toughness of 4.05 per cent and 0.454MPam/m, respectively (Choi et al., 2017).

2.1 Properties of hardened concrete:

Fibre reinforced concrete governs the properties of hardened concrete such as strength, ductility and toughness. Reinforce are provided to introduce the tensile strength into the concrete. The application of discontinuous discrete Nylon fibre are being increasingly used to enhance the static and dynamic tensile strength and energy absorbing capacity. The adaptation of Nylon fibre with different shapes increasing the bonding strength within the concrete matrix and hereby provide better fatigue strength. Investigation and study has been speculated on the mechanical strength and performance of the Nylon fibre reinforced concrete as the concrete gains enough strength at certain age after the proper casting and curing of the concrete test specimen.

Fiber reinforce concrete has various types of advantages, these are-

- Fiber helps to increase fatigue strength in reinforcing concrete.
- Fiber helps to reduce the growth of the crack in the structure besides that it helps to increase the impact strength of the structure.
- Fiber helps to increase the durability of concrete.
- As compared with non-fiber reinforced concrete, FRC has more tensile strength.
- Fiber also improves the resistance power of concrete which resists freezing.

Besides of various advantages of fiber reinforced concrete, there are some disadvantages, these are-

- Due to heavy rain fiber may be exposed from the structure.
- Randomly orientation of fiber in concrete may result in poor quality of concrete if fiber is not distributed uniformly.

Fibers are generally used to control dry shrinkage crack and plastic shrinkage crack. Fiber also lowers the permeability of concrete which helps to reduce water bleeding. Some specific fiber has a huge impact on concrete such as shatter and aberration resistance. Technically, fibers cannot increase the flexural strength of concrete so they cannot replace moment resistance in structural steel. Some of the fiber may reduce the strength of concrete.

2.2 The necessity of fiber reinforced concrete:

Reinforce cement concrete is considered a composite material. Therefore the use of fiber in RCC helps the structure a lot to increase the strength. In concrete fiber provides excellent resistance creep towards the structure. Fiber also performs as tendons / rebars in concrete. In addition fibers in concrete works as a crack arrester and significantly improve the dynamic and static properties of the structure. Besides of that, there are some necessary parameter of fiber, these are- • Fiber increases the durability power of the concrete.

- Fiber helps to reduce voids such as air and water inside of concrete.
- Fiber helps to increase the tensile strength of the concrete.

2.3 Affecting properties of fiber reinforced concrete:

Fiber-reinforced is a composite material which consists of fiber in a cement mixture in an orderly distributed manner. For better performance of fiber in the concrete mixture, it required efficient transfer of stress in between fiber and matrix. Besides of that, it depends of some factors these are-

- Stiffness.
- Volume of fiber.
- Orientation of fiber.
- Workability.
- Size of coarse aggregate.
- Mixing.

2.4 Types of fiber reinforced concrete:

There are various types of fiber although the following types of fibers are generally used in the construction industry. These are-

- Steel fiber.
- Natural fiber
- Glass fiber
- Nylon fiber.

3. Methodology

The use of fiber reinforced concrete is currently one of the most common practices in the quest to provide greater durability and service life to reinforced concrete structures, especially when exposed to aggressive environments. FRC work mainly in the refinement of the pore structure of concrete, providing greater mechanical strength and less penetrability to harmful agents. Three of fiber used in concrete such as NF, PEF and PPF. Because of these materials have high reactivity and, therefore, significantly increase the compressive strength of concrete.

The systematic approach to studying the gaps identified in the literature survey will be followed. Step by step methodology of the proposed work is as follows.

- Design of Concrete Mix as per IS: 10262-2009.
- Addition of the same percentages of nylon fiber, polypropylene fiber and polyethylene fiber.
- The casting of Concrete Cubes and beams.
- Testing the cube and beam specimens such as compressive and flexural strength.

Here I consider For M25 Concrete, and the Experimental Percentage Ratio taken as,

W/C= 0.50 and the comprehensive strength we get after 7, 14 and 28 days, are greater than M25 Concrete with replacement of cement.

Cement, Fine and Coarse Aggregate needed for M25 grade concrete:

SL No.	Materials	Quantity
1	Cement	380 kg
2	Fine aggregate	717 kg
3	Coarse aggregate (20 mm)	1170 kg
4	Water	190 L

To find the design mix ratio, divide the calculated value of all materials by the weight of cement. Therefore Mix Design Ratio of M25 Grade concrete by weight is Cement: F.A:C.A:Water=1: 1.9:3.1: 0.50

<u>Trial Details of Cubes Based on various fiber:</u>

- Here fiber varies by weight of 2.5% binder material.

Materials	Quantity	No. of cube	No. of beam
OPC 53	7.486 kg		
CA	23.05 kg		
FA	14.125 kg	**3**	**1**
WATER	3.6 lit		
FIBER	187 gm		

<u>Tests to be conducted:</u>

For Fine Aggregate-

- Sieve Analysis.
- Specific Gravity test.
- Bulking test

For workability of Concrete

- Slump cone test.
- Tests on Concrete.

Strength test

- Tensile strength test.
- Compressive strength test.

3.1 Basis of selection for OPC 53 Cement:

- High compressive strength in the early stages.
- Low alkali content provides better protection against alkali-aggregate reactions.
- High early strength facilitates speedy construction.
- Superior resistance to sulfate attack due to less C_3A.

3.2 Basis of selection for Fine aggregate Zone II:

- Fine Aggregates are totals that give dimensional steadiness to the blend.
- The flexible modulus and scraped spot obstruction of the solid can be impacted with a fine total.
- Fine Aggregates are survived in impact the blend extents and solidifying properties.
- The properties of fine totals likewise significantly affect the shrinkage of the solid
- It assists in producing workability and uniformly in the mixture.
- It assists the cement paste in hard the coarse aggregate particles.
- It helps to prevent possible segregation of paste and coarse aggregate, particularly during the transport operation of concrete for a long distance.
- Fine aggregate reduces the shrinkage of binding material.
- It prevents the development of a crack in the concrete.
- It fills the voids existing in the coarse aggregate and helps in increasing the density of concrete.
- It assists in hardening by allowing the penetration of water through its voids.

3.3 Basis of selection for Benefits of 20mm coarse aggregate:

- Benefits of Using the Maximum Size of Aggregates in Concrete
- Reduction of cement content is used to make concrete and thereby saving cost.
- Reduction in water requirement.
- Reduction of drying shrinkage.
- Reduction of void content.
- Construction and demolition waste is fed into our recycling plant.
- Oversized materials (anything larger than 100mm) are removed and any remaining metals are removed using a large magnet. Process of screening the aggregates through a variety of sieves to create a 4-10mm, 10-20mm, and 20-40mm product. The recycled aggregates are delivered via conveyor belt to their respective stockpiles.

Chapter III

1. Experimental setup & Procedure:

The idea behind the new experimental setup is to focus on the requirements of the project and find the most suitable solution. The experimental setup needs to be designed in a way that there is airflow passing through the paper and the paper can be heated.

1.1 Machine Requirement

1.1.1 Semi-Automatic Compression Testing Machine:

Compressive strength test of brick, cement mortar, concrete, and other building materials. It can also be used for mechanical properties tests of other materials. The computer controls the lifting of the machine screw without manual operation. **Semi-automatic compression testing machine** adopts hydraulic loading, electronic force measurement, load digital display, maximum load maintenance, and power-off data protection functions. Automatic test data processing and printing out test reports.

- High stability welded assembly.
- Piston stroke with safety limit switch.
- Platen hardness of min 55 HRC.
- Distance pieces and safety door included.
- Ball seating assembly and frame tested for stability

Semi-automatic compression testing machine

1.1.2 Flexural Testing Machine:

The Flexure Strength Testing Machines are designed to test flexural strength of concrete beams. The design provide maximum rigidity throughout their working range. The load is applied by the downward movement of the piston. A spacer is provided for testing different size of beams.

Flexural testing machine

1.2 Materials Required:

1.2.1 Fibers:

I. Polyethylene fiber.

Specification of Polyethylene Fiber	
Fiber length	60 mm
Specific gravity	1.12
Thermal conductivity	Low
Electrical conductivity	Low
Alkali resistance	100% Alkali Proof
Colour	White
Melting point	182^0 C
Acid & Salt resistance	High

II. Nylon fiber.

Specification of Nylon Fiber	
Fiber length	60 mm
Specific gravity	1.15
Thermal conductivity	Low
Electrical conductivity	Low
Alkali resistance	100% Alkali Proof
Melting point	225^0 C
Colour	Natural
Acid & Salt resistance	High

III. Polypropylene fiber

Specification of Polypropylene Fiber	
Fiber length	60 mm
Specific gravity	0.91
Thermal conductivity	Low
Electrical conductivity	Low
Alkali resistance	100% Alkali Proof
Diameter	19 micron
Melt point	162^0 C
Acid & Salt resistance	High
Colour	White

1.2.2 Cement:

OPC 53 Grade cement is required to conform to BIS specification IS: 12269-1987 with a designed strength for 28 days is a minimum of 53 MPa or 530 kg/sqcm. 53 Grade OPC provides high strength and durability to structures because of its optimum particle size distribution and superior crystallized structure. It means, that if cement mortar cubes are tested for compressive strength after 28 days, it should be more than 28 N/mm for OPC 53 grade cement.

RAMCO OPC 53 grade cement bag

1.2.3 Fine aggregate:

Fine aggregates are basically natural sand particles from the land through the mining process, the fine aggregates consist of natural sand or any crushed stone particles that are ¼" or smaller. This product is often referred to as 1/4'" minus as it refers to the size, or grading, of this particular aggregate. Aggregates less than 4.75 mm in size are called fine aggregates; sand falls under the fine aggregate and crushed stone or metal under the coarse aggregates. Here we will learn about fine aggregates, types of fine aggregates & much more. River Sand conforming Zone II as per IS 383:1970.

Fine Aggregate 20mm IS: 383:1970

1.2.4 Coarse Aggregate:

Coarse aggregates are irregular broken stones or naturally occurring round gravels that are used to make concrete, coarse aggregates for structural concrete consist of broken stones of hard rock like granite and limestone (angular aggregates) or river gravels (round aggregates). Aggregates larger than 4.75 mm in size are termed as coarse aggregates. These aggregates are obtained from stone quarries and stone crushers, the size between 4.75 mm to 80 mm. Single Sized Aggregate of Nominal Size 20 mm conforming IS 383:1970.

1.2.5 Water:

Water is the key ingredient, which when mixed with cement, forms a paste that binds the aggregate together. The water causes the hardening of concrete through a process called hydration.

1.2.6 Bucket:

Water buckets are used to carry water. Household and garden buckets are used for carrying liquids and granular products. Elaborate ceremonial or ritual buckets constructed of bronze, ivory, or other materials, found in several ancient or medieval cultures, sometimes known by the Latin for a bucket, situla.

1.2.7 Beam mould

The beam mould is used to prepare concrete specimens for flexural testing of concrete beams.

Beam mould

1.2.8 Slump Cone:

Slump Cones measure the workability of a fresh concrete mix in accordance with applicable ASTM and AASHTO standards. The slump cone test is performed for acceptance purposes, to record mixture characteristics, or as an indirect method of determining the water/cement ratio.

1.2.9 Cube:

Steel Concrete Cube Molds are used to form specimens for concrete compressive strength testing. They can also be used as sample containers in the determination of mortar set times as indicated in ASTM C403 and AASHTO T 197. 150x150mm is a one-piece mold made of steel with reinforced construction. Allows for easy specimen removal.

Cube

1.2.10 Water Bath:

A water bath is a laboratory equipment that is used to incubate samples at a constant temperature over a long period of time. The water bath is a preferred heat source for heating flammable chemicals instead of an open flame to prevent ignition.

Water Bath

1.2.11 Tamping Rod:

Tamping rods are dimensionally accurate rods used to tamp fresh concrete into concrete cylinder molds and grout sample boxes to eliminate voids and excess air.

1.2.12 Spade and Spatula:

A spatula is a broad, flat, flexible blade used to mix, spread and lift material including foods, drugs, plaster, and paints. In medical applications, "spatula" may also be used synonymously with a tongue depressor. The word spatula derives from the Latin word for a flat piece of wood or splint, a diminutive form of the Latin spatha, meaning 'broadsword', and hence can also refer to a tongue depressor. The words spade (digging tool) and spathe are similarly derived. a spatula is an admixing tool.

Spade and Spatula

1.2.13 Digital weighing Machine:

The digital electronic weighing scale is a device used to measure mass or weight. It works with the use of a strain gauge load cell. If you see analog scales, use springs to indicate the weight of the object, while digital scales convert the force of a weight to an electric signal.

Digital Weighing Machine

1.2.14 Sieve:

A sieve, fine mesh strainer, or sift, is a device for separating wanted elements from unwanted material or for controlling the particle size distribution of a sample, using a screen such as a woven mesh or net or perforated sheet material. The word sift derives from the sieve. In cooking, a sifter is used to separate and break up clumps in dry ingredients such as flour, as well as to aerate and combine them. A strainer, meanwhile, is a form of sieve used to separate suspended solids from a liquid by filtration.

Sieve

Chapter IV

1. Experimental Data

MIX DESIGN M25

.Mix design of M25 Grade Concrete as per Indian standard codebooks – IS10262 -CONCRETE MIX PROPORTIONING – GUIDELINES and IS456.

I. STIPULATIONS FOR PROPORTIONING

This section has the conditions or requirements that are specified or expected from the concrete. Change the values in this section as per your requirements to do the Mix design of M25 grade concrete.

1	Grade Designation	M25	IS 10262-2009
2	Type of Cement	OPC 53	IS-12269-1987
3	Maximum Nominal Size of Coarse Aggregate	20mm	IS 383 (1970)
4	Minimum Cement Content	300kg	Table 5-IS456
5	Maximum Cement Content	450kg	As per clause8.2.4.2
6	Maximum W/C ratio	0.50	Table 5-IS456
7	Workability	75mm	For RCC As per code

Table 5 Minimum Cement Content, Maximum Water-Cement Ratio and Minimum Grade of Concrete for Different Exposures with Normal Weight Aggregates of 20 mm Nominal Maximum Size

(Clauses 6.1.2, 8.2.4.1 and 9.1.2)

Sl No.	Exposure	Plain Concrete			Reinforced Concrete		
		Minimum Cement Content kg/m³	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete	Minimum Cement Content kg/m³	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete
1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Mild	220	0.60	–	300	0.55	M 20
iii)	Moderate	240	0.60	M 15	300	0.50	M 25
iii)	Severe	250	0.50	M 20	320	0.45	M 30
iv)	Very severe	260	0.45	M 20	340	0.45	M 35
v)	Extreme	280	0.40	M 25	360	0.40	M 40

NOTES

1 Cement content prescribed in this table is irrespective of the grades of cement and it is inclusive of additions mentioned in 5.2. The additions such as fly ash or ground granulated blast furnace slag may be taken into account in the concrete composition with respect to the cement content and water-cement ratio if the suitability is established and as long as the maximum amounts taken into account do not exceed the limit of pozzolona and slag specified in IS 1489 (Part 1) and IS 455 respectively.

2 Minimum grade for plain concrete under mild exposure condition is not specified.

Table 5 Minimum Cement Content, Maximum Water-Cement Ratio for Mix design of M25grade concrete – IS 456 codebook

II. TEST DATA FOR MATERIALS

Values in this section should be based on the laboratory tests on materials as per the relevant codebook. The values given here are standard values of day to day construction materials used in India.

1	Cement Used	OPC 53	Confirming to IS:8112
2	Specific Gravity of Cement	3.15	Test – IS: 2720
3	Specific Gravity of		Test – IS: 2386
3A	Coarse Aggregate	2.74	
3B	Fine Aggregate	2.74	
4	Water Absorption		Test – IS: 2386
4A	Coarse aggregate	0.5%	
4B	Fine aggregate	1%	
5	Sieve Analysis		Test – IS: 2386
5A	Coarse aggregate		Confirming to Table 2- IS: 383 (1970)
5B	Fine aggregate	Zone II	Confirming to Table 4- IS: 383 (1970)

III. TARGET STRENGTH

Mixing method, climate, curing and other factors may influence the strength of the concrete, hence it is important to design the concrete stronger than the actual strength needed for the construction. Target strength (f_{ck}) should be more than designed characteristic strength (f_{ck}). Target strength for M20 grade concrete can be found from the formula given in codebook.

$f'_{ck} = f_{ck}. +1.65 \text{ X } s$

f'_{ck} = target average compressive strength at 28 days,

f_{ck} = characteristics compressive strength at 28 days,

s = standard deviation value for the M25 grade concrete is given in table 1 of IS: 10262-2009.

Table 1 Assumed Standard Deviation
(*Clauses* 3.2.1.2, A-3 *and* B-3)

Sl No. (1)	Grade of Concrete (2)	Assumed Standard Deviation N/mm² (3)
i)	M 10	3.5
ii)	M 15	
iii)	M 20	4.0
iv)	M 25	
v)	M 30	5.0
vi)	M 35	
vii)	M 40	
viii)	M 45	
ix)	M 50	
x)	M 55	

NOTE — The above values correspond to the site control having proper storage of cement; weigh batching of all materials; controlled addition of water; regular checking of all materials, aggregate grading and moisture content; and periodical checking of workability and strength. Where there is deviation from the above, values given in the above table shall be increased by 1 N/mm².

Table 1 Standard Deviation for M25 grade Concrete – IS: 10262-2009 Codebook

$f'_{ck} = f_{ck} + 1.65 \times s$

$f'_{ck} = 25 + (1.65 \text{ X } 4)$ S = 4 (Table 1 of IS: 10262-2009)

$f'_{ck} = 25 + 6.6$

$f'_{ck} = 31.60 \text{ N/mm}^2$

Target strength we need for our concrete is 31.6 N/mm^2. i.e., after 28 days of curing in water, compressive strength of concrete should be at least more than 31.6 N/mm^2 when it is tested in the Direct Compressive Testing Machine (CTM).

IV. SELECTION OF WATER-CEMENT RATIO

The maximum water-cement ratio for M25 grade concrete can be found in Table 5-IS456 given above.

Maximum W/C ratio	= 0.50	Table 5-IS456
Adopted W/C ratio	= 0.50	

You can reduce the water-cement ratio for M25 grade concrete based on your requirements, but remember that the Water-cement ratio directly affects the concrete strength.

V. SELECTION OF WATER CONTENT

Maximum water content for 20mm aggregate to get up to 50mm slump is given in Table 2 of IS: 10262-2009.

Table 2 Maximum Water Content per Cubic Metre of Concrete for Nominal Maximum Size of Aggregate
(*Clauses* 4.2, A-5 *and* B-5)

Sl No.	Nominal Maximum Size of Aggregate mm	Maximum Water Content [1] kg
(1)	(2)	(3)
i)	10	208
ii)	20	186
iii)	40	165

NOTE — These quantities of mixing water are for use in computing cementitious material contents for trial batches.

[1] Water}content corresponding to saturated surface dry aggregate.

Table 2 Maximum Water Content per cubic meter – IS: 10262-2009

If we use 20mm aggregate we need the following water content to get 50mm slump

Maximum Water Content = 186 lit

But, as per the specification given in section 1, we need 75mm slump for our concrete. Clause 4.2 suggests that increasing water content by 3% will give extra 25mm slump from actual slump of 50mm.

Therefore, for 20mm aggregate to get 75mm slump:

Water-content for 75mm Slump = 186 + (0.03 X 186) (As per Clause 4.2)

= 186 + 5.58

≅ 191.58lit

Adopted Water Content = 192 lit.

VI. CALCULATION OF CEMENT

The weight of cement required for M25 grade concrete can be calculated from the water-cement ratio and the water content from the above calculations.

Adopted Water Cement Ratio = 0.50

Cement required = Water Content / Water Cement Ratio.

= 190 / 0.5

Adopted Cement Content = 380 kg

VII. COARSE AND FINE AGGREGATE

The coarse aggregate ratios for different zones of fine aggregates are given in Table 3 of IS: 10262-2009.

Table 3 Volume of Coarse Aggregate per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate

(*Clauses* 4.4, A-7 *and* B-7)

Sl No.	Nominal Maximum Size of Aggregate mm	Volume of Coarse Aggregate[1] per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate			
		Zone IV	Zone III	Zone II	Zone I
(1)	(2)	(3)	(4)	(5)	(6)
i)	10	0.50	0.48	0.46	0.44
ii)	20	0.66	0.64	0.62	0.60
iii)	40	0.75	0.73	0.71	0.69

[1] Volumes are based on aggregates in saturated surface dry condition.

Table 3 Volume of coarse aggregate to total aggregate ratio for Mix Design of M25 concrete – IS: 10262-2009.

As per specification, for

Maximum Nominal size of aggregate = 20mm.

Fine aggregate = Zone II.

Coarse Aggregate ratio = 0.62 **(Table3 IS: 10262-2009)**

Final Fine Aggregate ratio = 0.38

= 1 – 0.62

= 0.38

VIII. MIX CALCULATIONS OF M25 GRADE CONCRETE

This section deals with calculating the weight of fine aggregate and coarse aggregate needed for concrete from the aggregate ratios, cement and water.

Step: A

Volume of Concrete = 1 cu.m

Step: B

Total Volume of Cement = Cement / (Specific Gravity X 1000)

= 380 / (3.15 X 1000)

= 380 / 3150

≅ 0.1206 cu.m

Adopted Total Volume of Cement = 0.121 cu.m.

Step: C

Total Volume of Water = Water / (Specific Gravity X 1000)

= 190 / (1 X 1000)

= 190 / 1000

= 0.19 cu.m

Step: D

Total Volume Aggregates requirement = A – (B + C + D + E)

= 1 – (0.121 + 0.19)

= 1 – 0.311

= 0.689 cu.m

Step: E

Coarse Aggregate (C.A) = F. A. X C.A. X S.G X 1000

= 0.689 X 0.62 X 2.74 X 1000

≅ 1170.47 kg

= 1171 kg

Step: F

Fine Aggregate (F.A) = F. A. X Fine Aggregate Ratio X S.G X 1000

= 0.689 X 0.38 X 2.74 X 1000

≅ 717.38 kg

= 717 kg

Tests on Fine Aggregates

(Sieve analysis)

Aim of the Experiment:

Gradation of fine aggregate (fineness modulus) (IS 383 1970).

Test Standard Reference:

To determine the fineness modulus of fine aggregates by classifications based on IS: 383-1970.

Theory:

Fine aggregates in concrete serve the dual purpose of providing dispersed mass of cement paste much larger in volume to facilitate bonding of coarse aggregates as well as filling the voids amongst coarse aggregates. Higher percentage of coarse aggregates however means larger total surface area needing higher amount of cement for bonding. Very fine size particles are not desirable in high percentage from strength point of view. Therefore, fine aggregates should be taken in suitable proportion of coarse to medium to fine particle sizes. Sieve analysis is carried out to ascertain the gradients of particle size distribution.

Apparatus:

Set of IS sieve, weighing balance and trays.

Procedure:

1. Take 500 g of dry fine aggregate for sieve analysis by quartering from the test sample.
2. Place the material in the top of the sieve of largest size.
3. The stack of sieve should be arranged from top to bottom in sizes as shown in the observation table.
4. Allow sieving for about 10 minutes.
5. Weigh the aggregates retained on each sieve and carry out computations to determine particle size distribution and fineness modulus.

Sl No	Sieve Size (mm)	Mass Retained (g)	Mass Passing (g)	% retained	Cumulative % Retained	% Passing
1	10	0	100	0	0	100
2	4.75	11	489	2.2	2.2	97.8
3	2.36	34	455	6.8	9.0	91.0
4	1.18	47	408	9.4	18.4	81.6
5	0.600	126	282	25.2	43.6	56.4
6	0.300	178	104	35.6	79.2	20.8
7	0.150	94	10	18.8	98.0	2.0
8	Pan	3	7			

Hence Sand is conforming to Zone II as per IS: 383-1970

Tests on cement

Aim of The Experiment:

Determination of specific gravity of cement (IS 4031 (Part 11) 1988).

Theory:

The specific gravity of cement is the ratio of the weight of a given volume of substance to the weight of an equal volume of water. It is a number and denotes how many times a substance is heavy as water. To find the specific gravity of cement, it is required to find the weight of a certain volume cement and the weight of an equal volume of water. As cement reacts with water its specific gravity is determined with reference to a non-reactive liquid like kerosene.

Apparatus:

Le-Chatelier Flask (Specific gravity bottle), trowel, measuring jar, weighing balance, plate, rubber glove.

Procedure:

1. Weight of specific gravity bottle dry, W1

2. Fill the bottle with distilled water and weight it, W2

3. Dry the specific gravity bottle and fill it with kerosene and weight again, W3

4. Pour some of the kerosene out and introduce a weighted quantity of cement into the bottle.

5. Roll the bottle gently in the inclined position until no further air bubble rise to the surface.

6. Fill the bottle to the top with kerosene and weight it, W4.

Precautions:

1. only kerosene which is free of water is to be used.

2. All air bubbles shall be eliminated in filling the apparatus and inserting the stopper.

3. Weighing is to be done quickly after filling the apparatus and shall be accurate to 0.1 mg.

4. Precautions are to be taken to prevent expansion and overflow of the contents resulting from the heat of the hand when wiping the surface of the apparatus.

Tests on coarse aggregate

Sieve analysis

For M25 Concrete Experimental Data for Nylon fiber 2.5% use.

W/C= 0.5

Water required = (0.5 X380) = 190 lit

Coarse Aggregate ratio= 0.65

Final Fine Aggregate ratio = 1-0.65 =0.35

Mix Calculation:-

A. Volume of Concrete 1 m^3
B. Total Volume of Cement = Cement /(S.G X 1000)= 380/(3.15X 1000)= 0.121 m^3
C. Total Volume of Water = Cement /(S.G X 1000)= 133/(1X 1000)= 0.133 m^3
D. Total Aggregate Required = A-(B+C)= 1-(0.121+0.190)= 0.689 m^3
E. Coarse Aggregate (C.A)= F X C.A ratio X S.G X 1000= 0.689 X 0.62X 2.74 X 1000 = 1171 kg
F. Fine Aggregate (F.A)= FX C.A ratio X S.G X 1000= 0.689 X 0.38 X 2.74 X 1000= 717 kg

Materials	For 3 No. of Cubes & 1 No. of Beam
Cement	7.486 kg
Nylon Fiber	187 gm
Coarse Aggregate	23.05kg
Fine Aggregate	14.125 kg
Water	3.6 lit

After 7 days the compressive strength

Cube 1: F= P/A= 502.00/22.5= 22.31 N/mm²

Cube 2: F= P/A= 450.00/22.5= 20 N/mm²

Cube 3: F= P/A= 490.00/22.5= 21.77 N/mm²

After 14 days the compressive strength

Cube 1: F= P/A= 680.00/22.5= 30.22 N/mm²

Cube 2: F= P/A= 650.00/22.5= 28.88 N/mm²

Cube 3: F= P/A= 620.00/22.5= 27.55 N/mm²

After 28 days the compressive strength

Cube 1: F= P/A= 801.00/22.5= 35.6 N/mm²

Cube 2: F= P/A= 770.50/22.5= 34.24 N/mm²

Cube 3: F= P/A=750.25/22.5= 33.34 N/mm²

After 28 days the compressive strength (For Beam)

Mould 1 : F= P/A=184.50/22.5= 8.2 N/mm²

For M25 Concrete Experimental Data for Polypropylene Fiber 2.5% use.

W/C= 0.5

Water required = (0.5 X380) = 190 lit

Coarse Aggregate ratio= 0.65

Final Fine Aggregate ratio = 1-0.65 =0.35

Mix Calculation:-

A. Volume of Concrete 1 m^3
B. Total Volume of Cement = Cement /(S.G X 1000)= 380/(3.15X1000)= 0.121 m^3
C. Total Volume of Water = Cement /(S.G X 1000)= 133/(1X1000)= 0.133 m^3
D. Total Aggregate Required = A-(B+C)= 1-(0.121+0.190)= 0.689 m^3
E. Coarse Aggregate (C.A)= F XC.A ratioXS.GX 1000= 0.689X0.62X2.74X1000 = 1171 kg
F. Fine Aggregate (F.A)= FX C.A ratio X S.G X 1000= 0.689 X 0.38 X 2.74 X 1000= 717 kg

Materials	For 3 No. of Cubes & 1 No. of Beam
Cement	7.486 kg
Polypropylene Fiber	187 gm
Coarse Aggregate	23.05kg
Fine Aggregate	14.125 kg
Water	3.6 lit

After 7 days the compressive strength

Cube 1: F= P/A= 480.25/22.5= 21.34 N/mm²

Cube 2: F= P/A= 450.00/22.5= 20.44 N/mm²

Cube 3: F= P/A= 445.50/22.5= 19.8 N/mm²

After 14 days the compressive strength

Cube 1: F= P/A= 635.50/22.5= 28.24 N/mm²

Cube 2: F= P/A= 620.00/22.5= 27.56 N/mm²

Cube 3: F= P/A= 628.00/22.5= 27.91 N/mm²

After 28 days the compressive strength

Cube 1: F= P/A= 750.55/22.5= 33.36 N/mm²

Cube 2: F= P/A= 743.00/22.5= 33.02 N/mm²

Cube 3: F= P/A= 720.75/22.5= 32.03 N/mm²

After 28 days the compressive strength (For Beam)

Mould 1: F= P/A=168.70/22.5 ≅ 7.497 N/mm² = 7.5 N/mm²

For M25 Concrete Experimental Data for Polyethylene Fiber 2.5% use.

W/C= 0.5

Water required = (0.5 X380) = 190 lit

Coarse Aggregate ratio= 0.65

Final Fine Aggregate ratio = 1-0.65 =0.35

Mix Calculation:-

A. Volume of Concrete 1 m^3
B. Total Volume of Cement = Cement /(S.G X 1000)= 380/(3.15X1000)= 0.121 m^3
C. Total Volume of Water = Cement /(S.G X 1000)= 133/(1X1000)= 0.133 m^3
D. Total Aggregate Required = A-(B+C)= 1-(0.121+0.190)= 0.689 m^3
E. Coarse Aggregate (C.A)= F XC.A ratioXS.GX 1000= 0.689X0.62X2.74X1000 = 1171 kg
F. Fine Aggregate (F.A)= FX C.A ratio X S.G X 1000= 0.689 X 0.38 X 2.74 X 1000= 717 kg

Materials	For 3 No. of Cubes & 1 No. of Beam
Cement	7.486 kg
Polyethylene Fiber	187 gm
Coarse Aggregate	23.05kg
Fine Aggregate	14.125 kg
Water	3.6 lit

After 7 days the compressive strength

Cube 1: F= P/A= 502.00/22.5= 22.31 N/mm^2

Cube 2: F= P/A= 453.00/22.5= 20.13 N/mm^2

Cube 3: F= P/A= 490.00/22.5= 21.77 N/mm^2

After 14 days the compressive strength

Cube 1: F= P/A= 635.50/22.5= 27.82 N/mm^2

Cube 2: F= P/A= 620.00/22.5= 27.56 N/mm^2

Cube 3: F= P/A= 610.00/22.5= 27.11 N/mm^2

After 28 days the compressive strength

Cube 1: F= P/A= 711.43/22.5= 31.62 N/mm^2

Cube 2: F= P/A= 710.00/22.5= 31.56 N/mm^2

Cube 3: F= P/A= 711.73/22.5= 31.63 N/mm^2

After 28 days the flexural strength (For Beam)

Mould 1: F= P/A=155.22/22.5 ≅ 6.898 N/mm^2 = 6.9 N/mm^2

Chapter V

1. Results and Discussion:

1.1 Result of Compression test

Value of Nylon fiber N/mm^2				
Days	**Cube 1 (A)**	**Cube 2 (B)**	**Cube 3 (C)**	**Average Value X = (A+B+C)/3**
7 Days	22.31	20	21.77	21.09
14 Days	30.22	28.88	27.55	28.50
28 Days	35.6	34.24	33.34	30.17

This table shows average value of nylon fiber and also shows each cube value, where we can see that nylon fiber perform well in 28 days where its achieve 30.17 N/mm^2

Value of Polypropylene fiber N/mm^2				
Days	**Cube 1 (A)**	**Cube 2 (B)**	**Cube 3 (C)**	**Average Value X = (A+B+C)/3**
7 Days	21.34	20.44	19.80	20.59
14 Days	28.24	27.56	27.91	27.90
28 Days	33.36	33.02	32.03	32.80

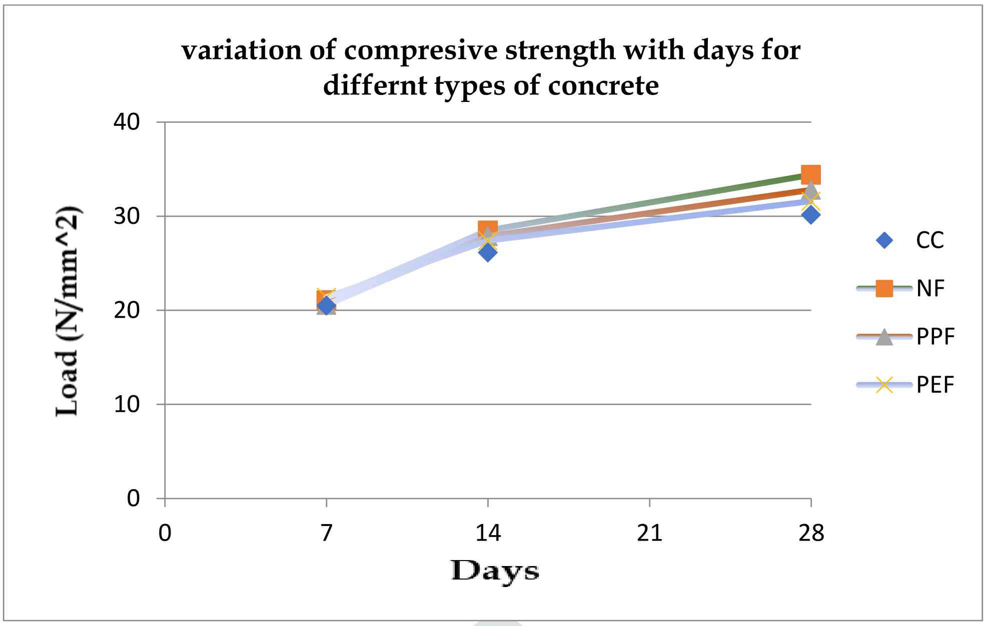
This table shows average value of polypropylene fiber and also shows each cube value, where we can see that PPE fiber perform well in 28 days where its achieve 33.36 N/mm^2.

Value of Polyethylene fiber N/mm^2				
Days	**Cube 1 (A)**	**Cube 2 (B)**	**Cube 3 (C)**	**Average Value X = (A+B+C)/3**
7 Days	22.31	20.13	21.77	21.40
14 Days	27.82	27.56	27.11	27.40
28 Days	31.62	31.56	31.63	31.60

This table shows average value of nylon fiber and also shows each cube value, where we can see that polyethylene fiber perform well in 28 days where its achieve 31.63 N/mm^2

*Cube test strength graph and result for 7,14 and 28 days.

Average compressive strength N/mm^2			
Sample	**7**	**14**	**28**
	days		
Control concrete	20.5	26.15	30.17
Nylon Fiber	21.09	28.5	34.4
Polypropylene Fiber	20.59	27.9	32.8
Polyethylene Fiber	21.4	27.4	31.6



Graph

This graph shows that difference between various fiber with control concrete where Nylon fiber takes more compressive strength than others fiber.

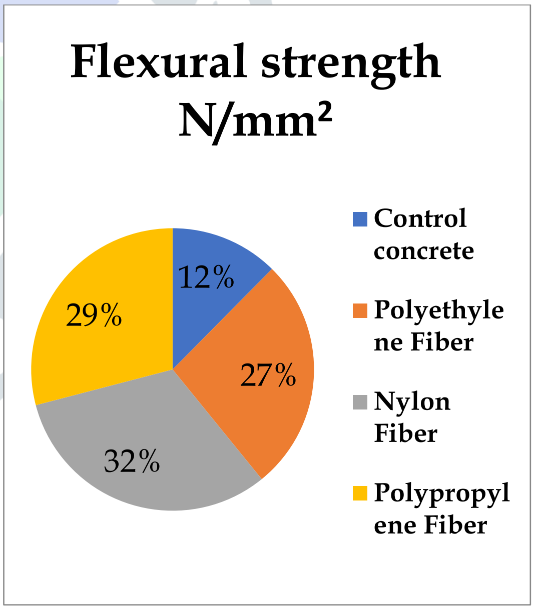
1.2 Result of Flexural test

This table shows 28 days value of flexural strength, where Nylon fiber takes better flexural strength.

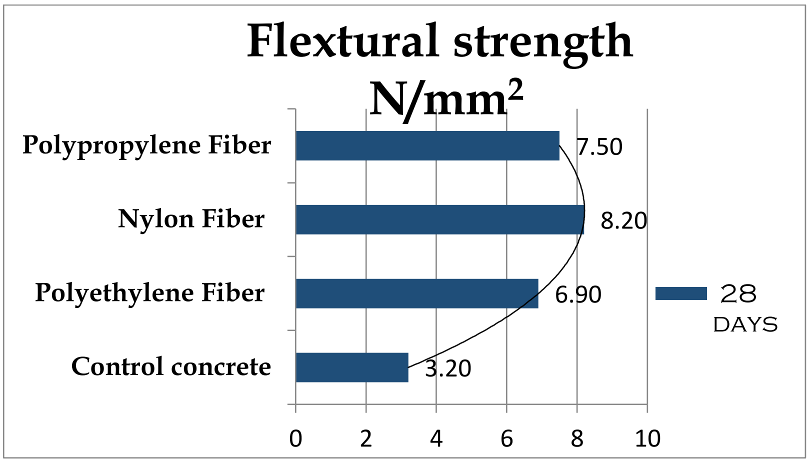
Value of Flexural strength N/mm^2	
Sample	**28 days**
Control concrete	3.2
Nylon Fiber	8.2
Polypropylene Fiber	7.5
Polyethylene Fiber	6.9

*Beam test strength graph and result for 28 days.

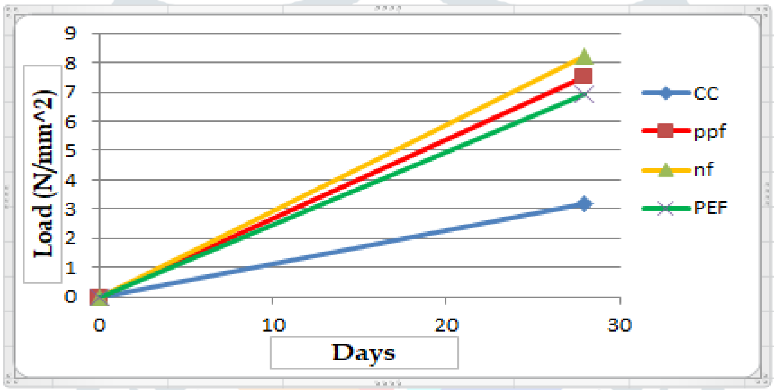
SL No.	Sample	Strength N/mm^2
1	Control concrete	3.2
2	Polyethylene Fiber	6.9
3	Nylon Fiber	8.2
4	Polypropylene Fiber	7.5



Pie chart



Bar chart



Graph

Chapter VI

1. Conclusion:

Fiber reinforced concrete can be used for a variety of applications. It is ideal for use in concrete applications that require protection from plastic and drying shrinkage, improved durability, increased service life and reduced construction costs. The main advantage of fiber-reinforced concrete is the reduction of shrinkage and cracking. The right fiber-reinforced concrete can also provide impact resistance, increase tensile strength and reduce voids in the concrete. The workability of FRC is low, but the durability of a structure is very high. The bridging actions of Fibers keeps the bond strength between Fiber and concrete, so the compound will stiffer. We can use FRC to reduce the depth of beam without loss of its bearing capacity.

FRC has high capacity of taking shear stress, bending moment than conventional concrete. Fibre-reinforced concrete has more tensile strength when compared to non-reinforced concrete. It increases the concrete's durability. It reduces crack growth and increases impact strength. Fibre-reinforced concrete improves resistance against freezing and thawing. Fiber-reinforced polymer composite offers not only high strength to weight ratio, but also reveals exceptional properties such as high durability; stiffness; damping property; flexural strength; and resistance to corrosion, wear, impact, and fire.

Here I used three types of fiber, where result and report show that Nylon fiber is better that other two fibers. It can bear good compressive and flexural strength

Chapter VII

1. Future Scope:

All the experiments have done for 7, 14, 28 days. In future Split Tensile Strength Test, Modulus of Elasticity of Concrete, For Durability test Rapid Chloride Penetration Test, Sulphate Resistance Test, Acid Resistance Test, Chloride Resistance Test are also necessary.

- The workability of the concrete with fibres was found to be very less. Hence, it can be improved to have a better slump value. Thus, certain admixtures such as air entraining agents and super plasticizers can be used so as to improve the flow characteristics of concrete.
- Hand mixing becomes very tedious and leads to formation of a non homogeneous mix. Certain chemicals can be added so as to replace hand mixing by machine mixing.
- Admixtures can also be used to reduce the number of voids which are formed to the present of fibres in the concrete. It may help improve the strength characteristics of concrete.
- It was found that the results did not improve by addition of fibres beyond 5% of the weight of cement in the mix. Hence, the optimum increase in the strength of concrete by addition of fibres lies between addition of fibres between 0% and 3% of the weight of cement in the mix.

Chapter VIII

1. Photo gallery

v

Chapter IX

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