Study of the Properties of Concrete Using Pine Needles – A Natural Supplement

Project Report submitted in partial fulfillment of the requirement for

the degree of

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in

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under the Supervision of

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CERTIFICATE

This is to certify that project report entitled "**Behaviour Of Concrete Using Pine Needles**", submitted by "**Siddhant chaudhary** and **keshav goyal** "in partial fulfillment for the award of degree of Bachelor in Civil Engineering to Jaypee University of Information Technology, Waknaghat, Solan has been carried out under my supervision.

We would like to express deepest appreciation towards **Prof. Dr. Ashok Kumar Gupta**, Head of Department of Civil Engineering.

This work has not been submitted partially or fully to any other University or Institute for the award of this or any other degree or diploma.

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Abbreviations and Symbols

MPa	Mega Pascal
M35	Grade of Concrete Having 35 MPa Strength
Fa	Fine Aggregate Content
P_f	Sand Content as percentage of total Aggregates
Ao	Percentage air content in concrete
Ca	Coarse aggregate content
T.M.S.	Target Mean Strength
fck	Characterstic strength

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Abstract

Concrete is the most widely used construction material in the world and steel reinforcement is always required to meet tensile strength and ductility demands of concrete structures. The production of concrete and reinforced concrete structures creates lots of environmental issues associated with the significant release of CO2 and other greenhouse gases. In addition, the corrosion of steel reinforcement is one of the major challenges that current civil engineers are facing. In the United States, the upgrading of civil infrastructure due to steel corrosion has been estimated as several trillion dollars. Thus, it is urgent to promote sustainable concrete and structures to reduce their negative impact on the environment.

The development of new environmentally friendly materials to replace steel rebar as reinforcement for concrete structure is a significant step to achieve sustainable concrete and structures. In this chapter, two types of sustainable concrete structures considering the use of natural fibres as reinforcement of concrete and concrete structures were introduced, i.e. Coir Fibre Reinforced Concrete (CFRC) mortar-free structures and Flax Fibre Reinforced Polymer tube encased Coir Fibre Reinforced Concrete (FFRP-CFRC) composite structures. The static and dynamic properties of these structure were studied.

It was found that natural fibres in different configurations can be used to replace conventional steel rebar as reinforcement of concrete structures. In addition, both sustainable concrete structures show good potential to be used in earthquake-prone zones. The application of these sustainable concrete structures is beneficial for consuming less energy, releasing less greenhouse gases into the atmosphere, and costing less to build and to maintain over time.

CHAPTER-1

INTRODUCTION

1.1 GENERAL

Concrete is no longer made of aggregates, Portland cement and water only. Often, if not always it has to incorporate at least one of the additional ingredients such as admixtures, supplementary cementious material or fibers to enhance its strength and durability. During last few decades requirement of high performance and highly durable concrete has been on rise.

It is only during last few years that the significance of eco-friendly materials has been realized all over the world to a greater extent. Principally these traditional ancient materials have rapidly evolved over the last decade, due to their environmental friendly advantages. Natural fibres have been used in the past as a raw material for different applications. In recent years, greater attention has been paid to their use in a number of applications including these fibres as reinforcing materials for polymer matrices. At present, natural fibre reinforced polymer composites materials are gradually replacing materials such as metal, ceramics, glass, etc. in the various industrial fields. The use of natural fibres, derived from a number of renewable resources as reinforcing fibres in both thermoplastic and thermoset matrix composites provides positive environmental benefits and offer numerous advantages over conventional materials including lightness, resistance to corrosion, ease of processing, etc.. The advantages of natural fibres over conventional fibre reinforcements such as glass fibres include low cost, non-corrosive, low density, reduced wear in processing equipment, good specific properties, high toughness, biodegradability and most important is their ecological friendliness because these natural fibres can be produced from renewable resources.

The inherent biodegradability of natural fibres also means that it is important to control the environment, in which the polymers are used to prevent premature degradation. Natural fibres are widely used in polymeric materials to improve mechanical properties. Natural fibres (e.g. cotton, flax, hemp, jute) can generally be classified as bast, leaf or seed-hair fibres.

Himachal Pradesh being a hilly state is blessed with vast natural fibrous materials. Because of inaccessibility to these hilly areas, such precious wealth of nature is not still exploited commercially for better end use. Among various types of natural fibres, pine needles have high potential as a reinforcing material in polymer matrices based composites.

1.2 INGREDIENTS OF CONCRETE

Concrete is made up of two components, aggregates and paste. Aggregates are generally classified into two groups, fine and coarse, and occupy about 60 to 80 percent of the volume of concrete. The paste is composed of cement, water, and entrained air and ordinarily constitutes 20 to 40 percent of the total volume.

1.3 CEMENT

Portland Cements and Blended Cements are hydraulic, since they set and harden to form a stonelike mass by reacting with water. The term Hydraulic Cement is all inclusive and is the newer term to be used for both Portland cement and Blended cement.

The invention of Portland cement is credited to Joseph Aspdin, an English mason, in 1824. He named his product Portland cement, because it produced a concrete which resembled a natural limestone quarried on the Isle of Portland.

The raw materials used in the manufacturing of cement consist of combinations of limestone, marl or oyster shells, shale, clay and iron ore. The raw materials must contain appropriate proportions of lime, silica, alumina, and iron components. Selected raw materials are pulverized and proportioned in such a way that the resulting mixture has the desired chemical composition. This is done in a dry process by grinding and blending dry materials, or in a wet process by utilizing a wet slurry. In the manufacturing process, analyses of the materials are made frequently to ensure a uniform high quality Portland cement.

After blending, the prepared mix is fed into the upper end of a kiln while burning fuel, producing temperatures of 2600 degree Fahrenheit to 3000 degree Fahrenheit, is forced into the lower end of the kiln. During the process, several reactions occur which result in the formation of Portland Cement clinker. The clinker is cooled and then pulverized. During this operation gypsum is added as needed to control the setting time of the cement. The pulverized finished product is Portland Cement. It is ground so fine that nearly all of it passes a sieve having 40,000 openings per sq. inch (1.6 openings per mm2).

There are five types of Portland Cement (Types I, II, III, IV, V) and two types of Blended Cement (Types I-P, I-S). Each type is manufactured to meet certain physical and chemical requirements for specific purposes.

Table 1. Types of Cement

Type I	is a general-purpose cement. It is suitable for all uses when the special properties of the other types are not required.
Type II	Cement is used when sulfate concentrations in ground water are higher than normal. Type II will usually generate less heat at a slower rate than Type I or Normal cement. Therefore, it may be used in structures of considerable mass, such as large piers, heavy abutments, and heavy retaining walls. Its use will minimize temperature rise, which is especially important in warm weather pours.
Type III	is a high-early-strength cement which will develop higher strength at an earlier age. It is used when early form removal is desired. Richer mixes (higher cement content) of Types I and II may be used to gain early strength.
Type IV	Cement is used in massive structures, such as dams. This type of cement is used where the heat generated during hardening is critical.
Type V	Cement is used in concrete exposed to severe sulfate action, and is used mainly in the western section of the United States.
Type I-P	Blended cement is a combination of Portland Cement and a pozzolan. A pozzolan, such as fly ash, by itself has no cementing qualities, but when combined with moisture and calcium hydroxide (in the Portland Cement) it produces a cementing effect.
Type I-S	Blended cement is a combination of Portland Cement and blast-furnace slag. The slag constitutes between 25 and 65 percent of the weight of the blended cement.

Tricalcium Silicate 3 CaO.S1O2 = C3S

Dicalcium Silicate 2 CaO.S1O2 = C2S

Tricalcium Aluminate 3 CaO.Al2O3 = C3A

Tetracalcium Aluminoferrite 4 CaO.Al2O3.Fe2O3 = C4AF

It is not necessary to memorize these chemical formulas; however, do become familiar with the contribution each compound makes to the concrete.

Tricalcium Silicate hydrates and hardens rapidly and is largely responsible for initial set and early strength.

Dicalcium Silicate hydrates and hardens slowly and contributes to strength increases at ages beyond one week.

Tricalcium Aluminate causes the concrete to liberate heat during the Þ rst few days of hardening and it contributes slightly to early strength. Cement with low percentages of this compound are especially resistant to sulfates (Types II and Type V).

Tetracalcium Aluminoferrite formation reduces the clinkering temperature, thereby assisting in the manufacture of cement. It hydrates rapidly but contributes very little to strength.

Table 2. Chemical and Compound Composition and Fineness of Some Typical Cements

Types of Portland Cement		Potential Compound Composition %				Blaine Fineness m^2/kg
ASTM	CSA	C_3S	C_2S	C_3A	C_4AF	
I	Normal	55	19	10	7	370
II		51	24	6	11	370
III	High-Early Strength	56	19	10	7	540
IV		28	49	4	12	380
V	Sulfate-Resisting	38	43	4	9	380

1.4 MIXING WATER

Almost any natural water that is drinkable is satisfactory as mixing water for making or curing concrete. However, water suitable for making concrete may not necessarily be fit for drinking. The acceptance of acidic or alkaline waters is based on the pH scale which ranges from 0 to 14. The pH of neutral water is 7.0. A pH below 7.0 indicates acidity, and a pH above 7.0 indicates alkalinity. The pH of mixing water should be between 4.5 and 8.5.Unless approved by tests, water from the following sources should not be used:

1. Water containing inorganic salts such as manganese, tin, zinc, copper, or lead;
2. Industrial waste waters from tanneries, paint and paper factories, coke plants, chemical and galvanizing plants, etc.;
3. Waters carrying sanitary sewage or organic silt; and
4. Waters containing small amounts of sugar, oil, or algae.

Wash water can be reused in the concrete mixture provided it is metered and is 25 percent or less of the total water. A uniform amount of wash water must be used in consecutive batches, with subsequent admixture rates adjusted accordingly to produce a workable concrete that conforms to the specifications.

1.5 AGGREGATES

Aggregates must conform to certain requirements and should consist of clean, hard, strong, and durable particles free of chemicals, coatings of clay, or other fine materials that may affect the hydration and bond of the cement paste. The characteristics of the aggregates influence the properties of the concrete.

Weak, friable, or laminated aggregate particles are undesirable. Aggregates containing natural shale or shale like particles, soft and porous particles, and certain types of chert should be especially avoided since they have poor resistance to weathering.

1.6 OBJECTIVES

The main objectives of this research work were:

- Efficient employment of pine needles as reinforcement in the production of fibre concrete. - To study the effect of fibre dimension on the mechanical properties of the pine needles reinforced concrete.
- To study the mechanical properties of fibre reinforced concrete so as to assess the possibility of using these materials in a number of applications.

CHAPTER-2

LITERATURE REVIEW

2.1 GENERAL

The properties of natural fibres depend mainly on the source, age and separating techniques of the fibre. Himachal Pradesh being a hilly state is blessed with vast natural fibrous materials. Because of inaccessibility to these hilly areas, such precious wealth of nature is not still exploited commercially for better end use. Among various types of natural fibres, pine needles have high potential as a reinforcing material in polymer matrices based composites.

Since not much information is available in the literature therefore a comprehensive research programme has been started in our laboratory to synthesize pine needles-reinforced polymer composites using different polymer matrices. In the present work we report some of our investigations on the synthesis and study of various properties of pine needles-reinforced resorcinol-formaldehyde (RF) resin matrix based polymer biocomposites.

2.2 FIBROUS MATERIALS

Fibers are a class of hair-like materials that are continuous filaments or are in discrete elongated pieces, similar to pieces of thread. They can be used as a component of composite materials. They can also be matted into sheets to make products such as paper or felt. Fibers are of two types: natural fiber which consists of animal and plant fibers, and manmade fiber which consists of synthetic fibers and regenerated fibers.

Concrete is weak in tension and has a brittle character. The concept of using fibers to improve the characteristics of construction materials is very old. Early applications include addition of straw to mud bricks, horse hair to reinforce plaster and asbestos to reinforce pottery. Use of continuous reinforcement in concrete (reinforced concrete) increases strength and ductility, but requires careful placement and labour skill. Alternatively, introduction of fibers in discrete form in plain or reinforced concrete may provide a better solution. The modern development of fiber reinforced concrete (FRC) started in the early sixties. Addition of fibers to concrete makes it a homogeneous and isotropic material. When concrete cracks, the randomly oriented fibers start functioning, arrest crack formation and propagation, and thus improve strength and ductility.

2.3 TYPES OF FIBRES

Steel Fibers: Straight, crimped, twisted, hooked, ringed, and paddled ends. Diameter range from 0.25 to 0.76mm.

Glass Fibers: Straight, Diameter ranges from 0.005 to 0.015mm (may be bonded together to form elements with diameters of 0.13 to 1.3mm).

Natural Organic and Mineral Fibers: Pine needles, Wood, asbestos, cotton, bamboo, and Rockwool. They come in wide range of sizes.

Polypropylene Fibers: Plain, twisted, fibrillated, and with buttoned ends.

Other Synthetic Fibers: Kevlar, nylon, and polyester. Diameter ranges from 0.02 to 0.38mm.

2.4 NATURAL FIBRES

Natural fibres are greatly elongated substances produced by plants and animals that can be spun into filaments, thread or rope. Woven, knitted, matted or bonded, they form fabrics that are essential to society.

Like agriculture, textiles have been a fundamental part of human life since the dawn of civilization. Fragments of cotton articles dated from 5000 BC have been excavated in Mexico and Pakistan. According to Chinese tradition, the history of silk begins in the 27th century BC. The oldest wool textile, found in Denmark, dates from 1500 BC, and the oldest wool carpet, from Siberia, from 500 BC. Fibres such as jute and coir have been cultivated since antiquity.

While the methods used to make fabrics have changed greatly since then, their functions have changed very little: today, most natural fibres are still used to make clothing and containers and to insulate, soften and decorate our living spaces. Increasingly, however, traditional textiles are being used for industrial purposes as well as in components of composite materials, in medical implants, and geo- and agro-textiles. Fourteen of the world's major plant and animal fibres are explained in table. They range from cotton, which dominates world fibre production, to other, specialty fibres such as cashmere which, though produced in far smaller quantities, have particular properties that place them in the luxury textiles market.

The advantages of natural fibres over conventional fibre reinforcements such as glass fibres include low cost, non-corrosive, low density, reduced wear in processing equipment, good specific properties, high toughness, biodegradability and most important is their ecological friendliness because these natural fibres can be produced from renewable resources.

Himachal Pradesh being a hilly state is blessed with vast natural fibrous materials. Because of inaccessibility to these hilly areas, such precious wealth of nature is not still exploited commercially for better end use. Among various types of natural fibres, pine needles have high potential as a reinforcing material in polymer matrices based composites.

2.4.1 TYPES OF THE NATURAL FIBRES

Table 3. PLANT FIBRES AND ANIMAL FIBRE

Plant fibres	Animal fibres
Plant fibres include seed hairs, such as cotton; stem (or bast) fibres, such as flax and hemp; leaf fibres, such as sisal; and husk fibres, such as coconut.	Animal fibres include wool, hair and secretions, such as siil.
1**.Pines** are conifer trees inthe genus ***Pinus*** in the family Pinaceae. They are the only genus in the subfamily Pinoideae**.** Pine needles have high potential as a reinforcing material in polymer matrices based composites.	1.A domesticated member of the South American camelid family, the **alpaca** numbers 3 million head worldwide. Shorn annually, an alpaca produces about 3 kg of fibre.
2.The **cotton** fibre grows on the seed of a variety of plants of the genus Gossypium. Of the four cotton species cultivated for fibre, the most important are hirsutum, which originated in Mexico and produces 90% of the world's cotton**.**	2.The **angora** is a variety of the Old World domestic rabbit with a special characteristic: the active phase of hair growth is double that of normal rabbits.
3. **Flax** fibres obtained from the stems of the plant Linum usitatissimum are used mainly to make linen. The plant has been used for fibre production since prehistoric times.	3.The two-humped Bactrian **camel** is native to the steppes of Eastern and Central Asia. The current herd size is estimated at 1.4 million animals.

4. Hemp fibre is obtained from the bast of the plant Cannabis sativa L. It grows easily - to a height of 4 m - without agrochemicals and captures large quantities of carbon. Production of hemp is restricted in some countries, where the plant is confused with marijuana.	4. The only source of true **cashmere** is the kashmir goat native to the Himalayas. Its fine undercoat hair is collected by either combing or shearing during the spring moulting season. After sorting and scouring, the fibres are cleaned of coarse outer hairs.
5. Jute is extracted from the bark of the white **jute** plant, Corchorus capsularis and to a lesser extent from tossa jute. It flourishes in tropical lowland areas with humidity of 60% to 90%. A hectare of jute plants consumes about 15 tonnes of carbon dioxide and releases 11 tonnes of oxygen.	5."**Mohair**" is derived from Arabic. The goat in question, the Angora is thought to have originated in Tibet. Turkey was the centre of mohair textile production before the goat was introduced, during the 19th century, to southern Africa and the USA.
6. Native to East Asia and commonly known as China grass, **ramie** is a flowering plant of the nettle family. Its bark has been used for millennia to make twine and thread, and spun as grass-cloth.	**6. Silk** is produced by the silkworm. Fed on mulberry leaves, it produces liquid **silk** that hardens into filaments to form its cocoon. The larva is then killed, and heat is used to soften the hardened filaments so they can be unwound
7. Sisal fibre is obtained from Agave sisalana, a native of Mexico. The hardy plant grows well in a variety of hot climates, including dry areas unsuitable for other crops.	7. Sheep were first domesticated 1000 years ago. They currently number about1 billion head, in 200 breeds, worldwide. Sheep are shorn of their **wool** usually once a year.

Figure 1. Green pine needle and Dry pine needle

CHAPTER-3

EXPERIMENTAL STUDY

3.1 OBJECT OF TESTING

The main objective of testing was to know the behavior of concrete with addition of pine needles as fibrous material at room temperature.
The main parameters studied were compressive strength, split tensile strength, flexural strength.

The materials used for casting concrete samples along with tested results are described.

3.2 MOULDS

Beam of size 100mm*100mm*500mm were used to prepare the concrete specimens for the determination of compressive strength concrete. Care was taken during casting and vibrator was used for proper compaction.

Cylindrical mould of size 150 mm*300 mm were used to prepare the concrete specimens for the determinations of split tensile strength and compressive strength. All the specimens were prepared in accordance with Indian Standard Specifications IS: 516-1959.All the moulds were cleaned and oiled properly. These were securely tightened to correct dimensions before casting. Care was taken that there is no gaps left from where there is any possibility of leakage out of slurry.

3.3 MIX DESIGNATION

The mix design for M35 Grade of Concrete for pile foundations provided here is for reference purpose only. Actual site conditions vary and thus this should be adjusted as per the location and other factors.

Grade of concrete: M35
Characteristic Strength (fck) : 35 MPa
Target Mean Strength: T.M.S.= fck + 1.65 * S.D.
(From I.S 456-2000) = 35 + 1.65*1.91
= 38.15 MPa

Aggregate type: Crushed

Specific gravity
Cement: 3.15
Coarse aggregates: 2.67
Fine aggregates: 2.62

MIX DESIGN

Take Sand content as percentage of total aggregates = 36%

Select Water Cement Ratio = 0.43 for concrete grade M35

(From Fig 2. of I.S. 10262- 1982)

Select Water Content = 172 Kg
(From IS: 10262 for 20 mm nominal size of aggregates Maximum Water Content = 186 Kg/ M^3)
Hence, Cement Content= 172 / 0.43 = 400 Kg / M^3

Formula for Mix Proportion of Fine and Coarse Aggregate:

$1000(1-a_0) = \{(\text{Cement Content} / \text{Sp. Gr. Of Cement}) + \text{Water Content} + (F_a / \text{Sp. Gr.} * P_f)\}$

$1000(1-a_0) = \{(\text{Cement Content} / \text{Sp. Gr. Of Cement}) + \text{Water Content} + C_a / \text{Sp. Gr.} * Pc)\}$

Where C_a = Coarse Aggregate Content

F_a = Fine Aggregate Content

P_f = Sand Content as percentage of total Aggregates

= 0.36

Pc = Coarse Aggregate Content as percentage of total Aggregates.

= 0.64

a_0 = Percentage air content in concrete (As per IS :10262 for 20 mm nominal size of aggregates air content is 2 %) = 0.02

Hence, $1000(1-0.02) = \{(400 /3.15) + 172 + (F_a / 2.62 \times 0.36)\}$

Fa = 642 Kg/ M^3

As the sand is of Zone II no adjustment is required for sand.

Sand Content = 642 Kg/ Cum

$1000(1-0.02) = \{(400 /3.15) + 172 + (C_a / 2.67 \times 0.64)\}$

Hence, **Ca = 1165 Kg/ M^3**

From combined gradation of Coarse aggregates it has been found out that the proportion of 53:47 of 20 mm & 10 mm aggregates produces the best gradation as per IS: 383.

Hence, 20 mm Aggregates = 619 Kg

And 10 mm Aggregates = 546 Kg

Cement : Sand: Coarse Aggregates = 1 : 1.6 : 2.907

CHAPTER -4

RESULTS AND DISCUSSION

4.1 General

Various properties of concrete were studied, results were compared and checked for compressive strength, split tensile strength. We are going to test M-35 grade concrete with different quantities of natural fibre pine needles.

4.2 Compressive Strength

According to IS 5816, compression test is the most common test conducted on hardened concrete, partly because it is an easy test to perform, and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength.

The compression test is carried out on specimens cubical or cylindrical in shape. Prism is also sometimes used, but it is not common in our country. Sometimes, the compression strength of concrete is determined using parts of a beam tested in flexure. The end parts of beam are left intact after failure in flexure and, because the beam is usually of square cross section, this part of the beam could be used to find out the compressive strength.

The cube specimen is of the size 15 x 15 x 15 cm. If the largest nominal size of the aggregate does not exceed 20 mm, 10 cm size cubes may also be used as an alternative. Cylindrical test specimens have a length equal to twice the diameter. They are 15cmin diameter and 30 cm long. Smaller test specimens may be used but a ratio of the diameter of the specimen to maximum size of aggregate, not less than 3 to 1 is maintained.

Out of many test applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not.

This concrete is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of these specimen should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen.

These specimens are tested by compression testing machine after 7 days curing or 28 days curing. Load should be applied gradually at the rate of 140 kg/cm2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.

HAND MIXING

(i)Mix the cement and fine aggregate on a water tight none-absorbent platform until the mixture is thoroughly blended and is of uniform color

(ii)Add the coarse aggregate and mix with cement and fine aggregate until the coarse aggregate is uniformly distributed throughout the batch

(iii)Add water and mix it until the concrete appears to be homogeneous and of the desired consistency

CURING

The test specimens are stored in moist air for 24hours and after this period the specimens are marked and removed from the molds and kept submerged in clear fresh water until taken out prior to test.

PRECAUTIONS

The water for curing should be tested every 7days and the temperature of water must be at 27+-2oC.

PROCEDURE

(I) Remove the specimen from water after specified curing time and wipe out excess water from the surface.

(II) Take the dimension of the specimen to the nearest 0.2m

(III) Clean the bearing surface of the testing machine

(IV) Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast.

(V) Align the specimen centrally on the base plate of the machine.

(VI) Rotate the movable portion gently by hand so that it touches the top surface of the specimen.

(VII) Record the maximum load and note any unusual features in the type of failure.

Table 4. Compressive Strength of plain M35 grade Concrete

COMPRESSIVE STRENGTH (MPa)				
M35 Grade Concrete	Cube 1	Cube 2	Cube 3	Average value
7th day	22.7	21.8	23.83	22.77
14th day	31.5	32.2	31.89	31.86
28th day	34.60	33.87	34.70	34.89

Table 5. Compressive Strength of M35 grade Concrete with 0.5% fraction of pine needles of total weight

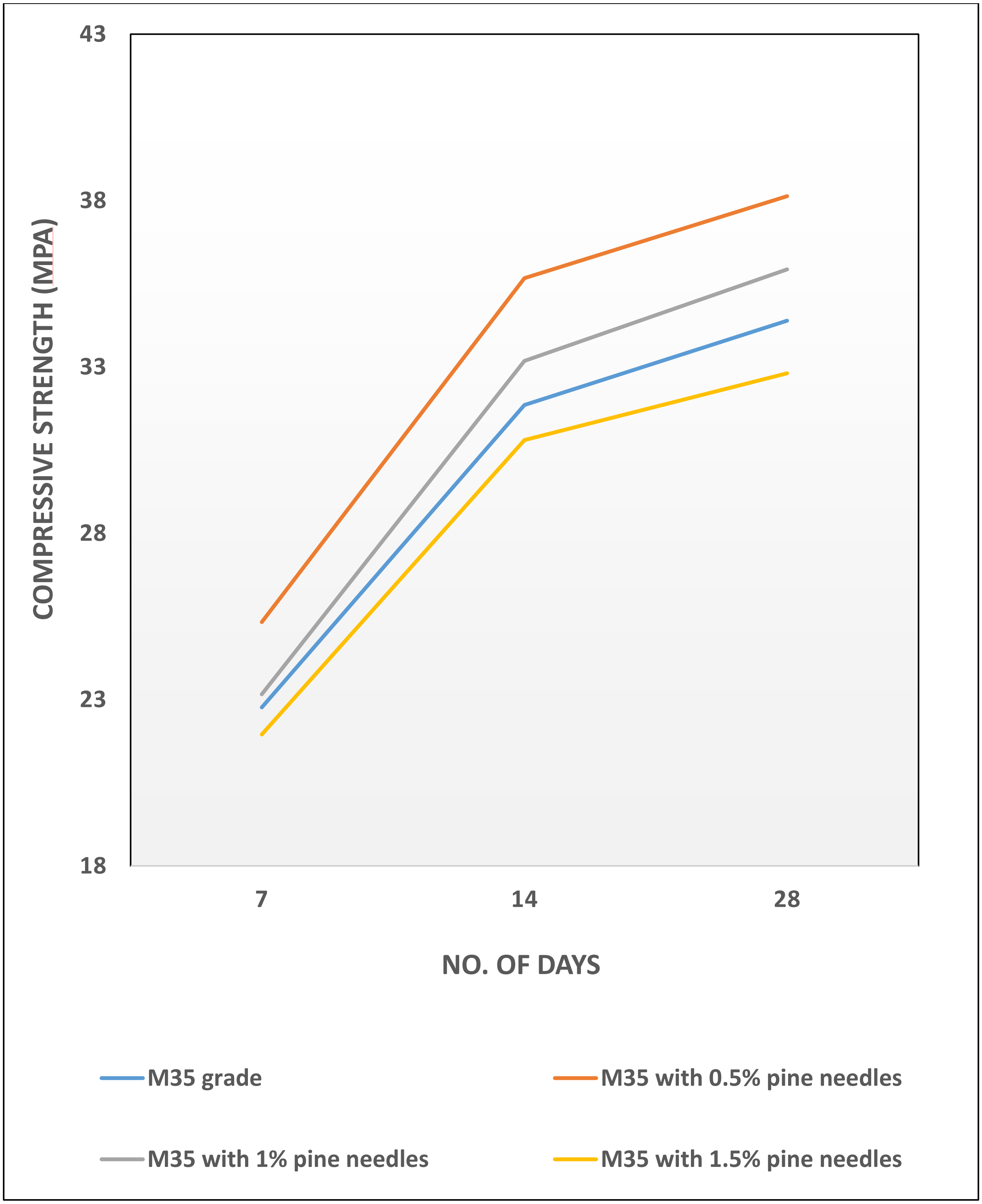
COMPRESSIVE STRENGTH (MPa)				
M35 Grade Concrete	Cube 1	Cube 2	Cube 3	Average value
7th day	25.30	24.80	25.90	25.33
14th day	34.08	36.50	35.70	35.67
28th day	38.10	38.50	37.80	38.13

Table 6. Compressive Strength of M35 grade Concrete with 1.0% fraction of pine needles of total weight

COMPRESSIVE STRENGTH (MPa)				
M35 Grade Concrete	Cube 1	Cube 2	Cube 3	Average value
7th day	23.1	22.90	23.50	23.16
14th day	33.35	32.80	33.60	33.18
28th day	36.10	35.90	35.78	35.93

Table 7. Compressive Strength of M35 grade Concrete with 1.5% fraction of pine needles of total weight

COMPRESSIVE STRENGTH (MPa)				
M35 Grade Concrete	Cube 1	Cube 2	Cube 3	Average value
7th day	21.80	21.50	22.57	21.95
14th day	30.30	31.23	30.87	30.80
28th day	32.80	32.93	32.70	32.81



Graph 1. Compressive Strength Vs No. of curing days with different quantities of fibre

4.3 Flexural Strength

According to IS 5816, the flexural strength of the specimen is expressed as the modulus of rupture fb which if ‘a’ equals the distance between the line of fracture and the nearer support, measured on the centre line of the tensile side of the specimen, in cm, is calculated to the nearest 0.05 MPa as follows: fb =***P* l*** **/ b*d^2**

When ‘a’ is greater than 20.0 cm for 15.0 cm specimen or greater than 13.3 cm for a 10.0 cm specimen, or

fb =**3p*a/b*d^2**

when ‘a’ is less than 20.0 cm but greater than 17.0 cm for 15.0 specimen, or less than 13.3 cm but greater than 11.0 cm for a 10.0 cm specimen where

b = measured width in cm of the specimen,

d = measured depth in cm of the specimen at the point of failure, l = length in cm of the span on which the specimen was supported, and p = maximum load in kg applied to the specimen.

If ‘a’ is less than 17.0 cm for a 15.0 cm specimen, or less than 11.0 cm for a 10.0 cm specimen, the results of the test be discarded.

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 6 x 6 inch (150 x 150-mm) 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 ConcreteFlexural 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%.

Table 8. Flexural Strength of plain M35 grade Concrete

FLEXURAL STRENGTH (MPa)				
M35 Grade Concrete	Beam 1	Beam 2	Beam 3	Average value
7th day	7.58	7.267	6.89	7.36
14th day	8.04	7.88	7.87	7.93
28th day	8.40	8.16	8.36	8.31

Table 9. Flexural Strength of M35 grade Concrete with 0.5% fraction of pine needles of total weight

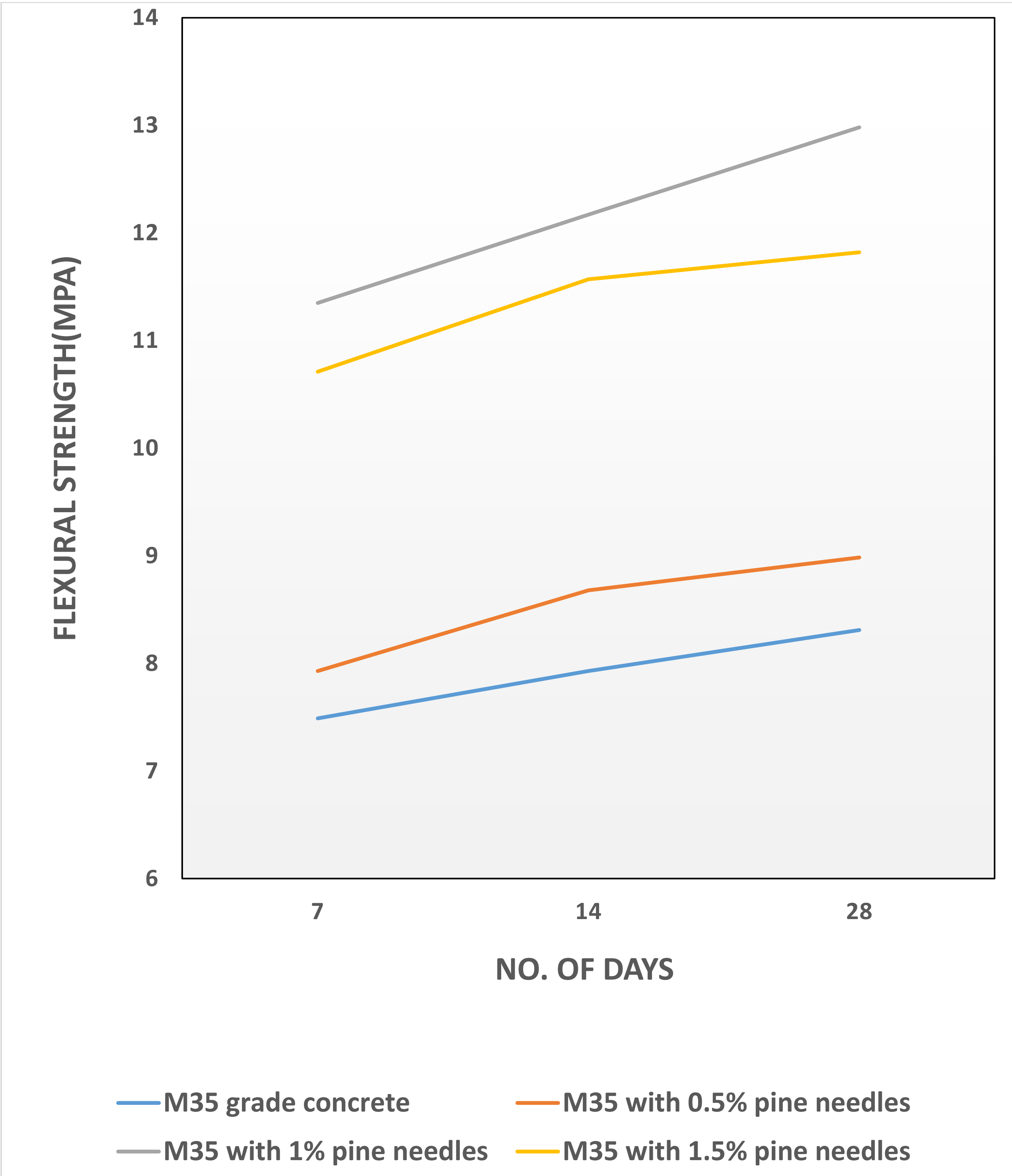
FLEXURAL STRENGTH (MPa)				
M35 Grade Concrete	Beam 1	Beam 2	Beam 3	Average value
7th day	8.07	7.57	8.15	7.93
14th day	8.93	8.24	8.86	8.67
28th day	9.12	8.81	9.02	8.98

Table 10. Table 9. Flexural Strength of M35 grade Concrete with 1.0% fraction of pine needles of total weight

FLEXURAL STRENGTH (MPa)				
M35 Grade Concrete	Beam 1	Beam 2	Beam 3	Average value
7th day	11.23	10.80	12.02	11.35
14th day	12.89	11.78	11.86	12.17
28th day	13.12	12.81	13.02	12.98

Table 11. Table 9. Flexural Strength of M35 grade Concrete with 1.5% fraction of pine needles of total weight

FLEXURAL STRENGTH (MPa)				
M35 Grade Concrete	Beam 1	Beam 2	Beam 3	Average value
7th day	10.23	11.63	10.14	10.71
14th day	11.72	12.03	10.98	11.57
28th day	12.23	11.71	11.53	11.82



Graph 2. Flexural Strength Vs No. of Curing days of beam with different quantities of fibre

Figure 2. Centre-point loading method (14 days)

Figure 3. Centre-point loading method (28 days)

4.4 Split Tensile Strength

According to IS 5816, cylinder Splitting Tension Test: This is also sometimes referred as, “Brazilian Test”. This test was developed in Brazil in 1943. At about the same time this was also independently developed in Japan.

The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of a compression testing machine and the load is applied until failure of the cylinder, along the vertical diameter.

Split tensile strength = **2P/Pi*L*D**

Where, P is the compressive load on the cylinder

L is the length of cylinder

D is its diameter

In order to reduce the magnitude of the high compression stresses near the points of application of the load, narrow packing strips of suitable material such as plywood are placed between the specimen and loading platens of the testing machine. The packing strips should be soft enough to allow distribution of load over a reasonable area, yet narrow and thin enough to prevent large contact area. Normally, a plywood strip of 25 mm wide, 3 mm thick and 30 cm long is used.

The main advantage of this method is that the same type of specimen and the same testing machine as are used for the compression test can be employed for this test. That is why this test is gaining popularity. The splitting test is simple to perform and gives more uniform results than other tension tests. Strength determined in the splitting test is believed to be closer to the true tensile strength of concrete, than the modulus of rupture.

COMPACTING

The test specimen should be made as soon as practicable after the concrete is filled into the mould in layers approximately 5 cm deep. Each layer is compacted either by hand or by vibration.

COMPACTING BY HAND

When compacting by hand, the standard tamping bar is used and the stroke of the bar should be distributed in a uniform manner. The number of strokes for each layer should not less than 30. The stroke should penetrate in to the underlying layer and the bottom layer should be rodded throughout its depth. After top layer has been compacted, the surface of the concrete should be finished level with the top of the mould,using a trowel and covered with a glass or metal plate to prevent evaporation.

CURING

The test specimen should be stored in a place at a temperature of 27° +/- 2°C for 24 +/- 0.5 hrs. from the time addition of water to the dry ingredients. After this period the specimen should be marked and removed from the woulds and immediately submerged in clean fresh water or saturated lime solution and kept there until taken out just prior to the test. The water or solution in witch the specimen s are kept should be renewed every seven days and should be maintained at a temperature of 27° +/- 2°c.

Concrete cylinder 15 cm diameter &3 0cm long.

PROCEDURE

1. Take the wet specimen from water after 7 days of curing
2. Wipe out water from the surface of specimen
3. Draw diametrical lines on the two ends of the specimen to ensure that they are on the same axial place.

4. Note the weight and dimension of the specimen.
5. Set the compression testing machine for the required range.
6. Keep are plywood strip on the lower plate and place the specimen.
7. Align the specimen so that the lines marked on the ends are vertical and centered over the bottom plate.
8. Place the other plywood strip above the specimen.
9. Bring down the upper plate to touch the plywood strip.
10. Note down the breaking load(P)

Figure 4. Split tensile test after 7 days curing

Figure 5. Split tensile test after 14 days curing

Figure 6. Split tensile test after 28 days curing

Table 12. Split Tensile Strength of plain M35 grade Concrete

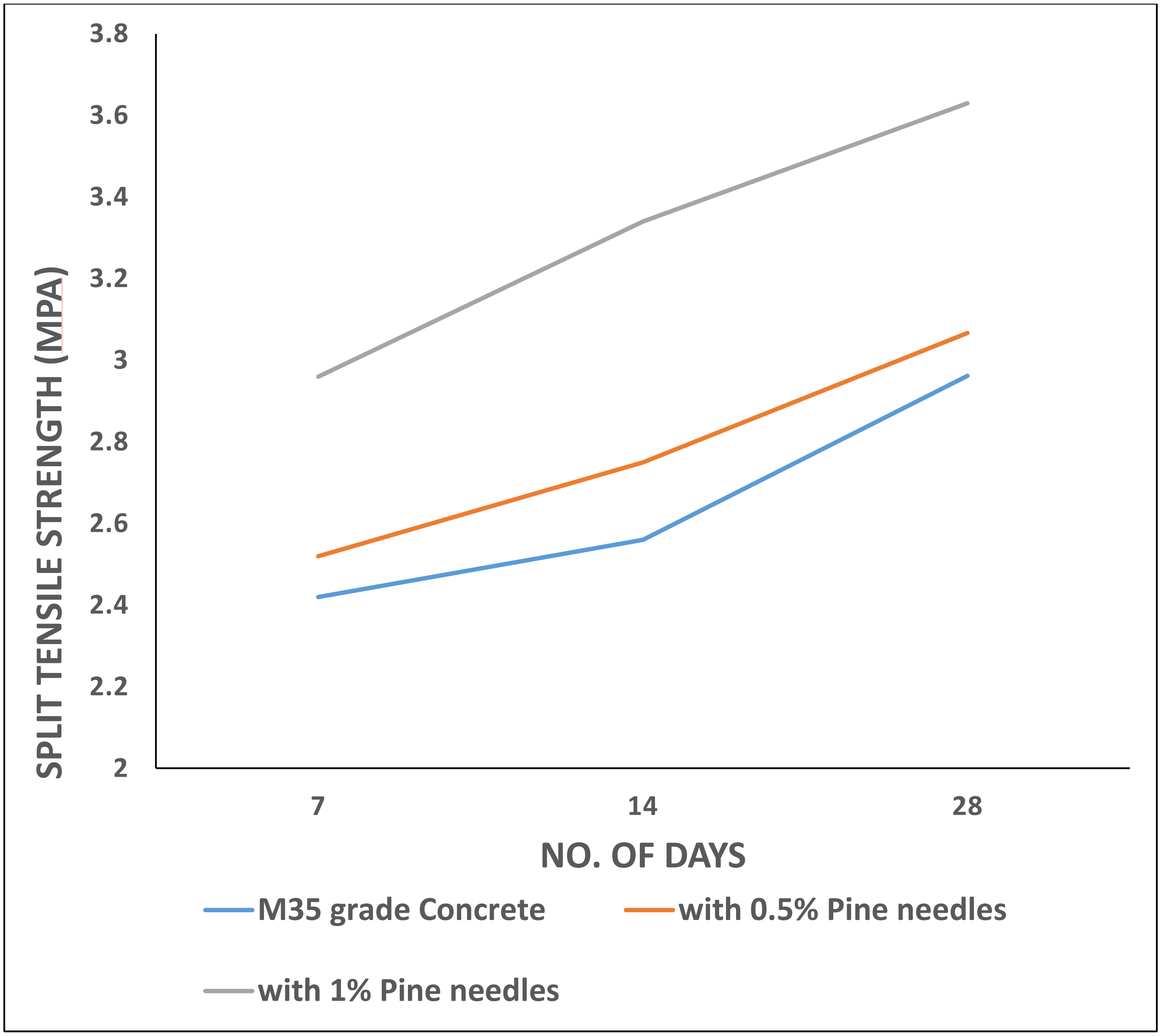
SPLIT TENSILE STRENGTH (MPa)				
M35 Grade Concrete	Cylinder 1	Cylinder 2	Cylinder 3	Average value
7^{th} day	2.4	2.476	2.417	2.42
14^{th} day	2.76	2.83	2.091	2.56
28^{th} day	3.043	3.085	2.76	2.962

Table 12. Split Tensile Strength of M35 grade Concrete with 0.5% fraction Of pine needles of total weight

SPLIT TENSILE STRENGTH (MPa)				
M35 Grade Concrete	Cylinder 1	Cylinder 2	Cylinder 3	Average value
7^{th} day	2.45	2.52	2.58	2.52
14^{th} day	2.81	2.90	2.54	2.75
28^{th} day	3.112	3.125	2.965	3.067

Table 12. Split Tensile Strength of M35 grade Concrete with 1.0% fraction Of pine needles of total weight

SPLIT TENSILE STRENGTH (MPa)				
M35 Grade Concrete	Cylinder 1	Cylinder 2	Cylinder 3	Average value
7th day	2.89	2.90	3.10	2.96
14th day	3.45	3.05	3.52	3.34
28th day	3.91	3.23	3.76	3.63

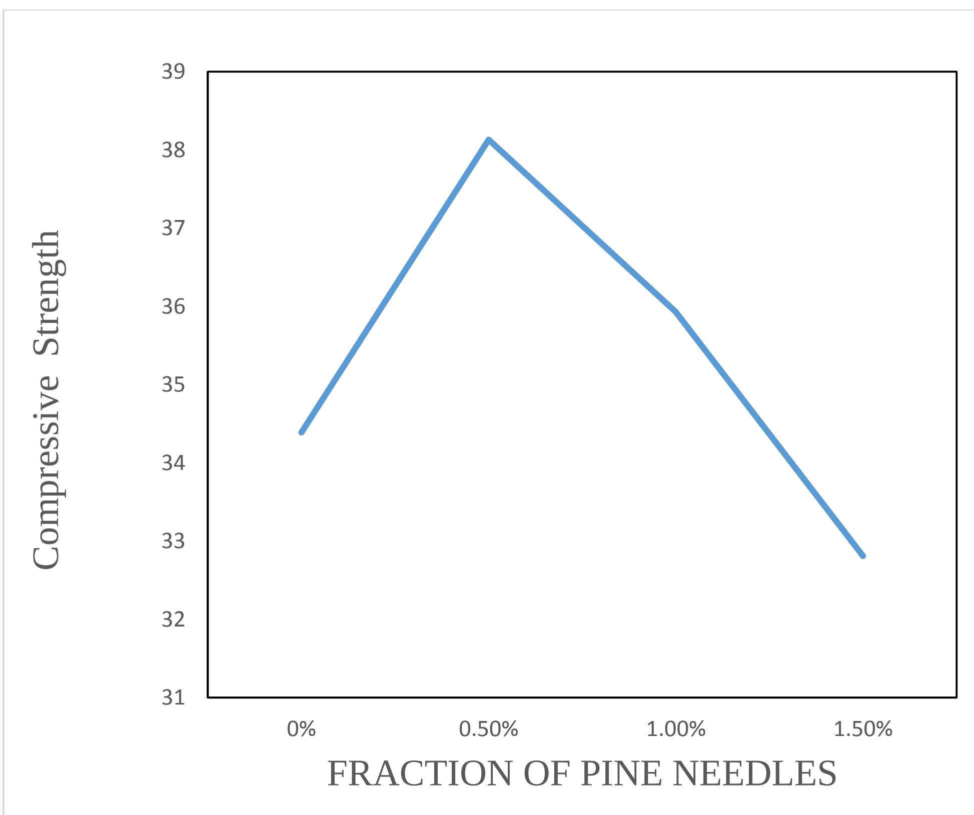


Graph 3. Split Tensile Strength Vs No. of Curing days of beam with different quantities of fibre

4.5 CONCLUSIONS

4.5.1 Compressive Strength

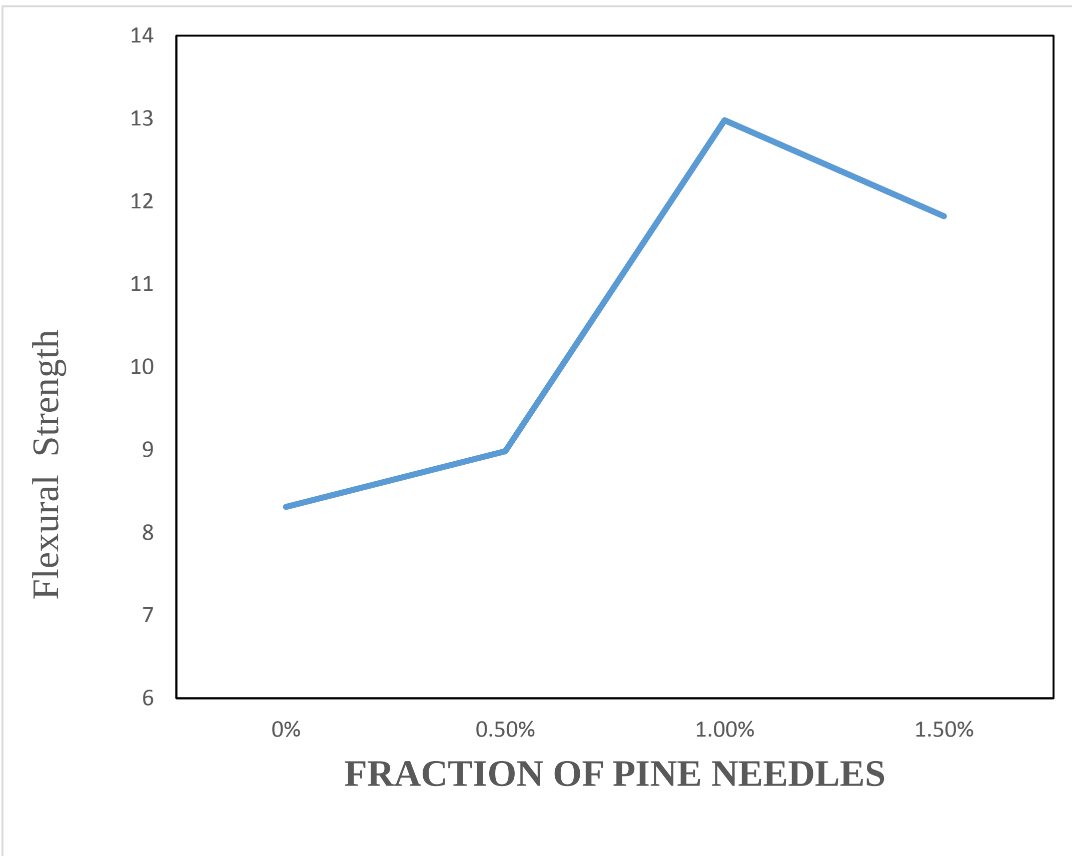
- The graph shows that, with increase in fraction of pine needles the value of compressive strength decreases.
- High fiber content composites can have reduced compressive strengths.
- Strength reduction most likely due to increased amount of entrapped air due to presence of fibers.
- From the literature, we know that volume fractions up to about 1% does not significantly affect compressive strength.
- On addition of 1.5% of pine needles of total weight of concrete the compreeive strength decreased up to 5.96%.



Graph 4. Compressive Strength Vs Fraction of Pine Needles

4.5.2 Flexural Strength

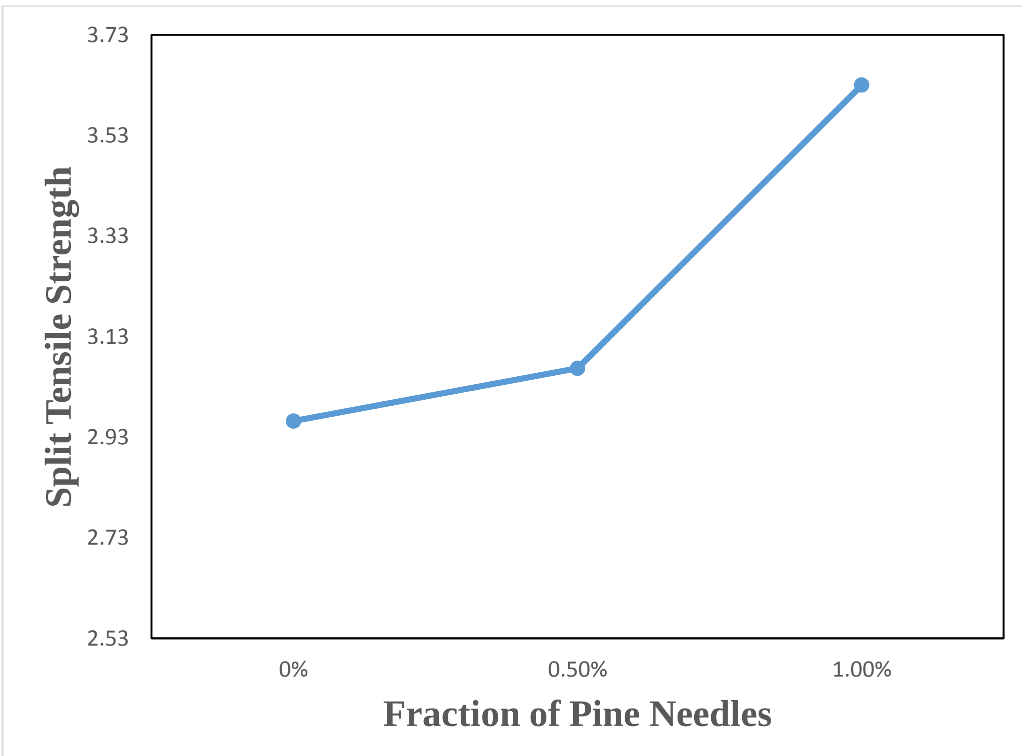
- The graph shows that, with increase in fraction of pine needles the value of flexural strength increases.
- But the value of flexural strength only increased to a limit, after that the value starts to decrease.
- On addition of 1.5% of pine needles of total weight of concrete the flexural strength increased up to 29.6%.



Graph 5. Flexural Strength Vs Fraction of Pine Needles

4.53 Split Tensile Strength

- The graph shows that, with increase in fraction of pine needles the value of split tensile strength increases.
- On addition of 1.5% of pine needles of total weight of concrete the split tensile strength increased up to 18.40%.



Graph 6. Split Tensile Strength Vs Fraction of Pine Needles

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