EXPERIMENTAL INVESTIGATION ON COMPRESSION, TENSION AND FLEXURAL STRENGTH OF JUTE FIBER REINFORCED CONCRETE.

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By

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DECLARATION

I hereby declare that this project is my work. Any use of the work of other persons has been appropriately identified and acknowledged.

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ACKNOWLEDGEMENT II

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ABSTRACT **III**

This paper presents experimental investigation of mechanical properties of jute fiber reinforced concrete. Compressive,Splitting tensile and Flexural test were performed with a jute fiber volume fraction ranging from 0.5 – 2%, 15cm fiber length and Aspect ratio(D/L) of 0.00066mm. A total of 80 specimens were taken for experimental investigation. Cylinders of standard dimension(150*300mm) are provided. Those provided cylindrical specimens are for conducting experiment on tensile and compression properties. Flexural strength test have been conducted on the prepared sample beams having a dimension of 100*100*500mm. Various amount of jute fiber similar to that cylindrical specimens are also considered in beams. The result of this experiment indicate that adding jute fiber in concrete generally enhance tensile and flexural strength, decrease compressive strength and workability and arrest cracks formation and propagation and ductility. So it can be concluded that concrete having jute fiber of length 15cm and 1.5% of its volumetric content have the optimal result for compression, Tension as well as Flexure.

NOTATION

Corchorus capsularis commonly known as white jute, is a shrub species. It's one of the sources of jute fiber

Latin upper case letters.

JFRCC	Jute Fiber Reinforced Concrete Composites.
42.5N	Description for Ordinary Portland cement.
EPC	Elephant Portland cement.
DC	Dangote Cement.
H_1	Thickness of silt content in the sand.
H_2	Thickness of total material layer which include fine aggregate and silt.
A	Area of provided specimen which might be cubic or cylindrical.
D	Diameter of cylindrical specimen.
V	Volume of provided specimen.
C15	Concrete grade which have ultimate compressive strength of 15 MPA.
C20	Concrete grade which have ultimate compressive strength of 20 MPA.
C25	Concrete grade which have ultimate compressive strength of 25 MPA.
C30	Concrete grade which have ultimate compressive strength of 30 MPA.
PCC (3)	Cylindrical specimen provided for compression test of 3 days.
0.5%C (3)	Cylindrical specimen, having 0.5% jute fiber, provided for compression test of 3 days.
1%C (3)	Cylindrical specimen, having 1% jute fiber, provided for compression test of 3 days.
1.5%C (3)	Cylindrical specimen, having 1.5% jute fiber, provided for compression test of 3 days.
2%C (3)	Cylindrical specimen, having 2% jute fiber, provided for compression test of 3 days.
σ	Splitting tensile strength, Mpa

P Maximum applied load indicated by test machine

L Length of specimen.

PCT (3) Cylindrical specimen (150*300mm), having 0% jute fiber, provided for tension test of 3 days.

0.5%T (3) Cylindrical specimen (150*300mm), having 0.5% jute fiber, provided for tension test of 3 days.

1%T (3) Cylindrical specimen (150*300mm), having 1% jute fiber, provided for tension test of 3 days

1.5%T (3) Cylindrical specimen (150*300mm), having 1.5% jute fiber, provided for tension test of 3 days

2%T (3) Cylindrical specimen (150*300mm), having 2% jute fiber, provided for tension test of 3 days

MR Modulus of Rupture. Other expression of flexural strength.

PCF (7) Beam (100*100*500mm), having 0% jute fiber, provided for flexure test of 7 days.

0.5%F (7) Beam (100*100*500mm), having 0.5% jute fiber, provided for flexure test of 7 days.

1%F (7) Beam (100*100*500mm), having 1% jute fiber, provided for flexure test of 7 days.

1.5%F (7) Beam (100*100*500mm), having 1.5% jute fiber, provided for flexure test of 7 days.

2%F (7) Beam (100*100*500mm), having 2% jute fiber, provided for flexure test of 7 days.

$A_{s, min}$ The minimum area of longitudinal tension reinforcement.

EBCS Ethiopian Building Code Standard.

$A_{s, actual}$ Actual area of longitudinal tension reinforcement.

A_C Area of cross section.

S_{max} Maximum longitudinal spacing between shear assemblies.

A_{sw} Area of shear reinforcement within length of the beam.

UTM Universal Testing Machine.

Latin lower case letters.

f_{cu} Compressive strength of concrete.

f_{ct} Tensile strength of concrete.

f_{ctm} Mean value of axial tensile strength of concrete.

f_{yk} Characteristic yield strength of reinforcement.

f_{ck} Characteristic compressive cylinder strength of concrete at 28 days.

b_t Mean width of the tension zone.

d Effective depth of cross section.

ρ_{min} Minimum reinforcement ratio.

ρ_{max} Maximum reinforcement ratio.

ρ_{actual} Actual reinforcement ratio.

$\rho_{w, min}$ Minimum shear reinforcement ratio.

ρ_w Shear reinforcement ratio.

Greek lower case letters.

α Inclination of the shear reinforcement to the longitudinal axis of the beam.

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CHAPTER 1

INTRODUCTION

1.1BACKGROUND

In developing countries, there has been an acute shortage of cheap but durable building materials for the construction of low-cost housing. The use of jute fiber reinforced cement composites may offer a possible Solution in this respect.

Ensete (which is family of jute)-based farming system is one of a major agricultural system in Ethiopia that serves as a back bone for at least one-fifth of the country's population. Ensete has been selected as a typical multipurpose crop of which every part is thoroughly used for food, feed, medicine, construction and ornamental purposes. Ensete is intimately is associated with the daily life of the farmers. Owing to these facts, farmers indicated that Ensete is everything to them.

Jute also is abundantly grown in Bangladesh, China, India, Indonesia and Thailand. It is extracted from a woody type of plant which grows to about 2 m high with a stem diameter ranging from 20 mm to 30 mm. Its bark consists of bundles of fibers running longitudinally down the stem. When harvested, the cut-stems are tied into bundles and kept submerged under water for 20 to 30 days. The tissues of the stems are then decomposed under bacterial action. The resulting soggy mass consisting of Strands of overlapping fibers are then stripped off manually, washed in water and dried under the sun.

Jute fiber being cheap, strong and durable, is a prospective reinforcing material for cement-based matrices. As concrete is weak in tension and has brittle character. The concept of using fibers to improve the characteristics of construction materials is very old. Use of continuous reinforcement in concrete (reinforced concrete) increase strength and ductility, but requires careful placement and labor skill. Alternatively introduction to fibers in discrete form in plane and reinforced concrete may provide better solution. When concrete cracks, and randomly oriented fibers start functioning, arrest cracks formation and propagation, and thus improve strength and ductility.

Concrete is non – linear, non elastic and brittle material. Its strong in compression and very weak in tension. Because it has essentially zero strength in tension,its always almost used as reinforced.It is also difficult to maintain strength of concrete and increase its ductility, so addition of natural fibers is economical way to increase strength of concrete. The type of fibers currently been used include steel, glass, polymers and natural fibers. Natural fibers have the potential to be used as reinforcement to overcome the inherent deficiencies in cementitious materials. Considerable researches are being done for use of reinforcing fibers like jute, bamboo and sugarcane in cement composites mostly in case of building materials. Use of natural fibers in a relatively brittle cement matrix has achieved considerable strength, and toughness of the composite.

This study was initiated to explore the feasibility of utilizing this jute fiber for producing fibrous composite in an attempt to solve, to some extent, the acute shortage of low-cost building materials in developing countries.

1.2. SCOPE OF THE STUDY

The scope of this project is to conduct experimental study on the flexural, tensile and compressive strengths of Jute Fiber-reinforced concrete (JFRC) with the hypothesis that "reinforcing concrete with jute fiber significantly improves the flexural, tensile and compressive strength of concrete."

The main source of data was test on provided sample specimens and the study was conucted for two(2) months

1.3.OBJECTIVE OF THE STUDY

In view of the specific objectives, this project has the following specific objectives:-

1. To carry out flexural, tensile and compressive strength tests on concrete reinforced with jute fiber.
2. To analyze the experimental results so as to determine the flexural, tensile and compressive strength properties of JFRC.
3. To assess the efficiency of the jute fiber as a reinforcement by evaluating the contribution in strength of JFRC specimens.
4. To study the properties of concrete by variation in percentage of jute fiber.

1.4. METHDOLOGY

It is the way to systematically solve the research problem. It may be understood as a science of studying hoe research is done scientifically. From those research techniques of analyzing documents, retrace related literatures and field researches, it’s preferred to conduct laboratory research method for a better and concrete judgments. So sample specimens are provided and each and every laboratory tests are conducted as per standard specification and reliable data is taken from it.

CHAPTER 2
LITERATURE REVIEW

Jute fiber is chosen as a natural fiber to replace by 1% weight of cement, it's chopped to the length of 6cm and a concrete (grade 40) of day 7 is used for the entire test. It is observed that the compressive strength of concrete is increased by 17.5% by adding raw jute, the split tensile strength of concrete is increased by 7% by adding raw jute and flexural strength of concrete is increased by 1% by adding raw jute.[Rahul R. Kshatriya1 (March 2016).]

The locally available raw jute fiber was used without any treatment. This jute fiber with four different cut lengths (10, 15, 20, and 25 mm) were applied with various volumetric percentages on concrete mixture. The different parameters of the concrete composites, the length, and volume fraction of the jute fiber content were used. The different lengths of fiber 10, 15, 20, and 25 mm and the contents 0, 0.1, 0.25, 0.50, and 0.75 % were used. Three different specimens: cubes (150 mm×150 mm× 150 mm), prisms (450 mm× 150 mm×150 mm), and cylinders (150 mm× 300 mm) were cast to determine the compressive, flexural, and tensile strength of the composites, respectively.

It can be stated that the remarkable enrichment of compressive strength is observed only for 10 and 15 mm fiber cut with 0.10 % volumetric content; however, the 25-mm fiber length causes the maximum strength loss of concrete composites. For 15 and 10 mm fiber length, 15 and 11 % increment of compressive strength is observed. And for 25 mm fiber length, for all percentage of jute fiber, its strength depreciate from a range of 10 – 60% compared to plane concrete.

On flexural test, the same outcome was observed, as the shorter fiber length and lower content reinforced concrete strength greatly whereas more fiber content and larger length resulted the easy failure of concrete. The highest strength augmentation up to 22 % was achieved for 15-mm fiber of 0.10 % dozing. For 25mm length and 0.5 to 0.75% of jute fiber the result still depreciated up to 38%.

On splitting test, for 15-mm fiber of 0.10 % dozing, the strength is improved up to 35%. For 25mm length and 0.75% of jute fiber the result still depreciated up to 43%.[Mohammad Zakaria (2016).]

2.1Properties of Ensete fiber (Ensete Ventricosum).

As a common feature, both Ensete and Muze have a large underground corm, a bundle of leaf sheaths (pseudo stem), and large paddle-shaped leaves. Although Ensete is thicker and larger than banana (often reaching up to 12 m in height and more than 1 m in diameter) both Ensete and banana are herbaceous perennial monocarpic crops. They produce flowers only once at the end of their life cycle. At the end of the life cycle of Ensete (9-14 years), the true stem emerges through the leaf sheaths, and forms multiple flowers, fruits and seeds.

Ensete plant grows in domestic as well as in wild forms. The domesticated Ensete is mainly propagated vegetative from suckers whereas most wild plants are produced from seeds, and the species appears to have an outcrossing reproductive system. This plant occurs in sub-Saharan Africa and grows wild in many countries in Central and Eastern Africa including Ethiopia, Congo, Mozambique, Uganda, Tanzania and Zambia. In Ethiopia, wild Ensete occurs in the highlands in the southwestern part whereas the cultivated Ensete grows in a wider area comprising the central, southern and southwestern parts of Ethiopia, but mainly at higher altitudes ranging from 1500 to 3100m.

Ensete is presently the main crop of a sustainable indigenous African system, which ensures food security and it is well known for its drought resistance. In Ethiopia alone, more than 20 percent of the total population, concentrated in the highlands of southern Ethiopia, depend upon Ensete. Besides its use as a source of copious quantities of carbohydrate-rich food, Ensete is also utilized for fiber production, animal forage, construction materials, as an ornamental, and for its medicinal values, with a demonstrated antimicrobial activity against viral, bacterial, fungal and nematode diseases of humans.

Fig 2. 1:- Stem of plant Ensete Ventricosum with visible fibers, as harvested in Ethiopia.

- The mechanical properties of the jute fiber are the most favorable for its load bearing applications.
- Jute is environment friendly and gives off a very low level of harmful substances.
- Renewable and inexpensive material.
- Resistant towards fracture, has low density, high strength, low elongation, no health hazard, and absorbs atmospheric carbon dioxide to grow.

- The choice of jute as a reinforcing fiber is mainly due to its good specific mechanical properties, low cost and good availability.
- It's one of a major agricultural system in Ethiopia that serves as a backbone for at least one-fifth of Ethiopia's population(Mangesh D. Teli and Jelalu M. Terega.2017).
- It's used as food, plate, roof cover, bed and cattle feed.
- It's used for medicine in the rural area.
- Due to high resistance to tensile force, it's used as one of ingredient for gypsum ceiling work.

Diameter (µm)	127.87
Tensile strength (MPa)	351.67
Moisture content (MC)	12.15

Table 2. 1:-Typical properties of Ensete fibers(Mangesh D. Teli and Jelalu M. Terega.2017).

2.2 Properties of jute fiber (Corchorus capsularis).

Jute is a long, soft, shiny fiber that can be spun into coarse and strong threads. It is one of the cheapest natural fibers. Both the fiber and the plant are commonly called jute; it is a rainy season crop that grows best in the warm, humid climates in India, China, and Bangladesh. Jute grows in alluvial soil, sand or loam soil, in areas with high temperatures and an annual rainfall of over 1000mm, and can survive in heavy flooding. Jute takes about three to four months after planting, and the harvesting begins after it blooms, but before the blossoms go to seed. People used to consume its leaves as vegetable and also a household herbal remedy. When the plants are about 6feet tall, they are thinned out and graded according to their color, strength and fiber length. The fiber is off white or brown in color about 3 to 6feet long, and pressed into bales for shipment to manufacturers. More than 97% of the world's jute is produced in Asia, including 65% in India and 28% in Bangladesh. Jute in India provides livelihood to around 4 million farmers and 362 thousand workers.

The rapid depletion of forests, causing environmental pollution, has forced people to use substitute material for wood. So on one hand, there is a great demand for a wood substitute, and on the other hand, for jute fiber due to its stiff competition in the traditional field with synthetic fibers. These two counter facts make enough sense to develop jute composite as a wood substitute. Both jute and wood have the same chemical composition, as they are very close to each other. The main difference between them is that, one is flexible and the other is rigid. The very flexible nature of jute fiber allows the scientists to develop molded composites, and at the same time to eliminate the fabrication cost.

Fig 2. 2:- Asian (Corchorus capsularis) jute plant

- Jute is a very good insulator of heat and electricity.
- It is the second most important vegetable fiber in terms of usage, global consumption, production and availability.
- Jute stem has a very high volume of cellulose that can be procured within 4-6 months, and hence, it can also save the forest and meet the cellulose and wood requirements of the world.
- Jute is a highly hygroscopic fiber.
- The chemical composition of the jute is different from that of linen, cotton and a modified form of cellulose called lignocellulose.
- Jute is colored yellow by iodine and sulphuric acid, and gives a blue color with dilute chromic acid in the presence of hydrochloric acid.
- Jute is more sensitive to the action of chemicals than cotton or linen.

Properties	Range of values
Fiber length, mm	180 - 800
Fiber diameter, mm	0.10 - 0.20
Specific gravity	1.02 - 1.04
Bulk density, kg/m^3	120 - 140
Ultimate tensile strength, N/mm^2	250 - 350
Modulus of elasticity, kN/mm^2	26 - 32
Elongation at fracture, percent	2 - 3
Water absorption, percent	25 - 40

Table 2. 2:-Typical properties of jute fibers(Mansur, M.A. and Aziz, M.A. 1988).

2.3 physical properties of cement.

Different blends of cement use in construction are characterized by their physical properties.

Finess of cement.

The sizes of the particles of the cement is its finess. The required finess of good cement is achieved through grinding the clinker in the last step of cement production process. As hydration rate of cement is directly related to the cement particle size, finess of cement is very important.

Soundness of cement.

Soundness refers to the ability of cement to not shrink up to hardening. Good quality cement retains its volume after setting without delayed expansion, which is caused by excessive free lime and magnesia.

Consistency of cement.

The ability of cement paste to flow is consistency. It’s measured by vicat test.

Strength test.

Three types of strength of cement are measured. Compressive, tensile and flexure. Various factors affect the strength, such as water cement ratio, cement – fine aggregate ratio, cement- fine aggregate ratio, curing conditions, size and shape of specimen, the manner of molding and mixing, loading conditions and age.

- Compressive strength: - it’s the most common strength test. A test specimen (50mm) is taken and subjected to a compressive load until failure. The load sequence must be within 20 second and 80 second.
- Flexural strength: - This is actually the measure of tensile strength in bending. The test is performed in a 40*40*160mm cement mortar beam, which is loaded at its center point until failure.
- Tensile strength: - though this test used to be common during the early years of cement production, now it doesn’t offer any useful information about the properties of cement.

Setting time of cement.

Cement sets and hardens when water is added. This setting time can vary depending on multiple factors, such as finess of cement, cement – water ratio, chemical content and admixtures. Cement used in construction should have an initial setting time that is not too low and a final setting time not too high. Hence, two setting times are measured. Initial setting time is when the paste begins to stiffen noticeably (typically occurs within 30-40 minutes) and final setting when the cement hardens, begins able to sustain some load (occurs below 10 hours).

2.4 properties of fine aggregate.

It's a granular material composed of finely divided rock and mineral particles. It's defined by size, being finer than gravel and coarse than silt. Sand can also refer to a texture class of soil or soil type. Sand can also be define as particle with a diameter between 0.075 and 4.75mm.

Advantages of sand

- It's used as ingredient for concrete.
- It's always used as a road base.
- It can be used in recreation facilities.

2.5 properties of coarse aggregate.

The physical properties of aggregates are those that refer to the physical structure of the particles that make up the aggregate.

Absorption, Porosity and Permeability.

The internal pore characteristics are very important properties of aggregates. The size, the number, and the continuity of the pores through an aggregate particle may affect the strength of the aggregate, abrasion resistance, surface texture, specific gravity, bonding capabilities, and resistance to freezing and thawing action. Absorption relates to the particle's ability to take in a liquid. Porosity is a ratio of the volume of the pores to the total volume of the particle. Permeability refers to the particle's ability to allow liquids to pass through. If the rock pores are not connected, a rock may have high porosity and low permeability.

Surface Texture.

Surface texture is the pattern and the relative roughness or smoothness of the aggregate particle. Surface texture plays a big role in developing the bond between an aggregate particle and a cementing material. A rough surface texture gives the cementing material something to grip, producing a stronger bond, and thus creating a stronger hot mix asphalt or Portland cement concrete. Surface texture also affects the workability of hot mix asphalt, the asphalt requirements of hot mix asphalt, and the water requirements of Portland cement concrete.

Some aggregates may initially have good surface texture, but may polish smooth later under traffic. These aggregates are unacceptable for final wearing surfaces. Limestone usually falls into this category. Dolomite does not, in general, when the magnesium content exceeds a minimum quantity of the material.

Strength and Elasticity.

Strength is a measure of the ability of an aggregate particle to stand up to pulling or crushing forces. Elasticity measures the "stretch" in a particle.

High strength and elasticity are desirable in aggregate base and surface courses. These qualities minimize the rate of disintegration and maximize the stability of the compacted material. The best results for Portland cement concrete may be obtained by compromising between high and low strength, and elasticity. This permits volumetric changes to take place more uniformly throughout the concrete.

CHAPTER 3

MATERIALS AND METHOD

3.1 MATERIA

Portland Pozzolona cement of C30 Grade was supplied by Dangote Cement Pvt. Ltd. Locally available coarse aggregate (stone chips of size 0 - 40 mm) and fine aggregate is supplied from local market available from river sand. Jute fibers also purchased from local market.

3.1.1Jute fibers

Jute is a kind of fiber obtained from plants known as white corchorus capsularis. The manufacturing process of jute fiber involves hand harvesting of the source plant, drying in the field for defoliation, retting for periods up to a month, stripping and sun drying. The tensile strength and extensibility of jute fiber were determined in the laboratory using texture analyzer.

Typical properties of jute -fibers are given in Table:-3.1.The basic requirements of any fiber for producing good quality fibrous concrete are high tensile strength, high elastic modulus.

3.1.1.1Properties of jute fiber.

- Fiber length is determined using tape measure.
- Fiber diameter is measured, taking 20 pcs of fiber at a time and measure its diameter and divide it with their number to find the diameter of single fiber. Finally check it using calibration. 4 sample is taken to be certain.
- Specific gravity is done at laboratory.
- Density is calculated by measuring a weight of 10 sample of jute fiber with specified volume.
- Tensile strength is measured at laboratory.
- Water absorption is determined alongside with specific gravity.

Properties	Range of values
Fiber length, cm	150-180
Fiber diameter, mm	0.1
Specific gravity	1.0178
Bulk density, kg/m^3	177.78
Ultimate tensile strength, N/mm^2	448.72
Water absorption, percent	3.75 times its weight

Table 3. 1:- Typical properties of jute fibers.

Fig 3. 1:- Row and chopped jute fiber

Specific gravity: - the specific gravity of jute fiber indicates the density relative to that of the water at 4^0C. We know that the specific gravity of water at 4^0C temperature 1000kg/m^3.

Density: - weight of 10 samples having a dimension of 5*5*4.5mm are taken and each samples Have a weight of 20g. So jute fiber have a density of 117.78kg/m^3.

Tensile strength: - is determine by analyzing the load that can be carried by a single jute and divide it by its cross sectional area. 3 trial tests are conducted for this property. For each tests (125,150,180,210,250,305,350 and 400 gram) loads are taken and for each cases loads that can exceed 350 gram are failed.

Water absorption: - while we determine water absorption of jute fiber, we realized that it can absorb water which can weight 3 times its weght.9 we take 20 gram of dry weight of jute and immerse it into water for 24 hours and weight it at its surface dry saturated weight and becomes75 gram)

3.1.2Cement (DANGOTE)

Cement is material which generally use for bonding in concrete in construction industries. We used .the Portland Pozzolana cement of 42.5N grade for our whole work. Before using some tests are carried on it. Some physical characteristics of cements are given in table 3.2

Cement type	Finess (%)	Setting time		Compressive strength(MPA)			Specific gravity (g/cm^3)
DANGOTE CEMENT		Initial time(min)	Final time(min)	7 days	14days	28days	
	12	60	165	22	25	30	3.06

Table 3. 2:- Physical characteristics of cement(Ogunbiyi Moses , Olawale Simon, Alabi Olusegun , Thanni Mubarak.2017).

3.1.3 Fine aggregate (River sand)

The river sand was used as fine aggregate. The river sand was washed and screened, to eliminate unwanted deleterious material and over size particles. The test for determination of particle size distribution and silt content was carried out. The surface dry aggregate were used for test. These properties of aggregate are necessary to decide proportions of the concrete mix.

Fig 3. 2:- River sand.

3.1.3.1 Sieve Analysis

In order to classify the fine and coarse aggregate for engineering purpose, one need to know the distribution of the size of the grains in the aggregate. Sieve analysis is a method used to determine the grain size distribution of the aggregates. Sieves ate made of woven wires with square openings. Note that as the sieve number increases the size if openings decrease.

Many natural and manufactured materials occur in a disperse form, which means that they consist of differently shaped and sized particles. The particle size distribution, i.e. the number of particle of different sizes, is responsible for important physical and chemical properties.

If the aggregate size is less than 4.75mm, then it’s called fine aggregate. The minimum size of fine aggregate is 0.075mm is preferred for concrete work.

Fine aggregate may be described as:-

- Natural sand: - it’s the aggregate resulting from the natural disintegration of rock and which has been deposited by streams.
- Crushed stone sand: - it’s the fine aggregate produced by crushing natural hard stone.
- Crushed Gravel sand: - it’s the fine aggregate produced by crushing natural gravel.

According to size, fine aggregate may be disrobed as

- Fine sand: -   its particle size distribution is ranging from 0.075mm to 0.425mm.
- Medium sand: - its particle size distribution is ranging from 0.425mm to 2mm.

- Coarse sand: - its particle size distribution is ranging from 2mm to 4.75mm.

Fig 3. 3:- particle size distribution for fine aggregate.

- Since the 95% of particle size distribution for this material is less than 4.75mm, then it's called Fine aggregate (sand). The minimum size of the sample fine aggregate is 0.15mm.
- Since particle size distribution of 74.28% is ranging from 0.425mm to 2mm.

= 10.27% is ranging from 2m to 4.75mm.

= 10.3% is ranging from 0.075 to 0.425mm. Therefore we can consider it as Medium sand.

3.1.3.2 Silt content

Silt content is a fine material which is less than 150 micron. It's unstable in the presence of water. If we use silty sand for bonding, it will reduce the strength.

- The clay and silt content may usually not exceed 6%.

To determine silt content of sand, put the sand into transparent jar, add water up to 50% above the sand level and shake the jar strongly for at least 30 seconds. Then Place the jar on a table at least one hour, when the water is clear, measure the thickness of the silt layer (H_1) and the thickness of the total material layer (H_2). And express silt content in percentage.

Fig 3. 4:-Silt content determination of sand.

- Silt content = 4% which is not exceed the allowable limit. So that is ok!!!!

3.1.3.3 Finess modulus of fine aggregate.

Finess modulus of sand (fine aggregate) is an index number which represents the mean size of the particle in sand. It’s calculated by performing sieve analysis with standard sieves. The cumulative percentage retained don each sieve is added and subtracted by 100 gives the value of finess modulus. Therefore, finess modulus of aggregate = (cumulative % retained)/100

$$= (230.91/100) = \underline{2.31}$$

- Finess modulus of fine aggregate is 2.31. It means the average value of aggregate is between the 2nd and 3rd sieve. It means the average aggregate size is in between 0.3mm to 0.6mm.

3.1.3.4 Specific gravity of fine aggregate.

Specific gravity (G) is defined as the ratio of the weight of aggregate in air to the weight of equal volume of water displaced by saturated surface dry aggregate. The specific gravity of fine aggregates normally used is ranges from 2.6 to 2.9.

Specific gravity = <u>2.67</u>, Allowable range is $2.6 \leq S.G \leq 2.9$--------OK!!!!

3.1.3.5 Water absorption of fine aggregate

It’s the ability of porous materials to retain a certain amount of liquid (water) in the air space.

Moisture content % = <u>3.06</u>% and most it’s recommended to be less than 3%.

3.1.4Coarse aggregate (crushed stone)

The coarse aggregate of 40mm from crushed ballast rock are used. The aggregates were free from injurious amount of disintegrated pieces, vegetable matter and other deleterious substances. Typically coarse aggregate sizes are larger than 4.75mm.

Fig 3. 5:- Coarse Aggregate.

3.1.4.1 Sieve Analysis

Fig 3. 6:- particle size distribution for coarse aggregate

- Since the 98.54% of particle size for this material passes 37.5mm sieve, then its called 40mm coarse aggregate.
- Also 99.36% of particle size is above 4.75mm sieve, which means its coarse aggregate.

3.1.4.2 Specific gravity of coarse aggregate

Specific gravity (G) is defined as the ratio of the weight of aggregate in air to the weight of equal volume of water displaced by saturated surface dry aggregate. The specific gravity of aggregates normally used in road construction ranges from 2.5 to 3.

Specific gravity of coarse aggregate = <u>2.74</u>, Allowable range is 2.5 ≤ S.G ≤ 3--------OK!!!!

3.1.4.3 Water absorption of coarse aggregate

It's the ability of porous materials to retain a certain amount of liquid (water) in the air space. The water absorption of aggregates ranges from 0.1 to 2% of its dry weight.

Moisture content % of coarse aggregate = <u>1.22</u>% and its b/n allowable range of 0.1 ≤ M.C ≤ 2.

3.2 METHOD

3.2.1 Problem of statement

Jute fiber is chosen as a natural fiber to replace by 0.5%, 1%, 1.5% and 2% weight of cement. And comparing in C30 grade plain cement concrete and raw jute cement concrete with various amount of jute content for compressive, split tensile and flexural strength.

3.2.2 Mixing process

The jute fiber reinforced concrete samples of mix design 1:0.75:1.5(cement: sand: coarse aggregate, by weight) were fabricated by following process, for untreated jute fiber reinforced concrete. Initially the jute fiber is chopped with proposed length and will be immerse 24 hours into water. While, we are ready to mix C30 concrete, the required amount of water, sand and aggregate is then added and the pan-mixer was run for enough time. Finally the chopped jute with required percent will be put into pan mixer.

3.2.3 Test to be carried out on specimen for different composite.

Sizes of specimen:-

Cylinder: - Height= 300mm, Diameter= 150mm.

Beam- 100mm X 100mm X 500mm.

Serial no	Type of concrete composition	Type of specimen	Test to be taken	Number of sample		
				3days	7days	28days
1	Plain cement concrete	Cylinderical	compression	2	2	2
2	JFRC with (0.5, 1, 1.5 and 2%)		compression	8	8	8
3	Plain cement concrete		Tension	2	2	2
4	JFRC with (0.5, 1, 1.5 and 2%)		Tension	8	8	8
5	Plain beam	Beam	Flexure		1	1
6	Beam with jute fiber of (0.5, 1, 1.5 and 2%)		Flexure		4	4
7	RC Beam		Flexure		1	1
8	RC Beam with jute fiber of (0.5, 1, 1.5 and 2%)		Flexure		4	4

Table 3. 3:- Test to be carried out on specimen for different composite for 3, 7 and 28days.

3.2.4 Mix design

$A = (\Pi * D^2)/4$

$= (3.14*0.15^2)/4 = 0.0176m^2$

$V = A*L = 0.0176m^2 * 0.3m$

$= 0.0053m^3$

Sample for 4 test having 0.5% jute fiber and grade C30 (1:0.75:1.5)

- $V = 12*0.0053m^3$ sum of ratio = 1+0.75+1.5 = 3.25

  $= 0.0636m^3$
- Dry volume = $1.54*0.0636m^3 = 0.0979m^3$

Quantity of cement

- Volume by m^3 = $0.0979m^3 * (1/3.25)$

  $= 0.03m^3$
- Volume by kg = $0.03m^3 * 1440\ kg/m^3$

  = 42.3 kg or (42.3kg/50kg/bag) = 0.864 bag

Quantity of sand

- Volume by m^3 = $0.0979m^3 * (0.75/3.25)$

  $= 0.023m^3$
- Volume by kg = $0.023m^3 * 1450\ kg/m^3$

  = 33.35 kg

Quantity of Aggregate

- Volume by m^3 = $0.0979m^3 * (1.5/3.25)$

  $= 0.045m^3$
- Volume by kg = $0.045m^3 * 1500\ kg/m^3$

  = 67.77 kg

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1:- Trial test for grade C30 (1:0.75:1.5)

The strength of concrete increases with age.

Age	Strength percent
1 day	16%
3 days	40%
7 days	65%
14 days	90%
28 days	99%

Table 4. 1:- the strength of concrete at different age compared to 28 days result.

Grade of concrete	Minimum compressive strength at day 3	Minimum compressive strength at day 7	Compressive strength at day 28
C12/15	6	10	15
C16/20	8	13.5	20
C20/25	10	17	25
C25/ 30	12	20	30

Table 4. 2:- Grades of concrete at 7 and 28 days.

The purpose of trial mix is to check the strength, workability, density and other properties of concrete mixes.

- V = (0.15*0.15*0.15*6*1.54)m^3
  = 0.0311m^3

sum of ratio = 1+0.75+1.5 = 3.25

Quantity of cement

- Volume by m^3 = 0.0311m^3 * (1/3.25) * 1440
  = 13.8kg

Quantity of sand

- Volume by m^3 = 0.0311 * (0.75/3.25) * 1450
  = 10.4kg

Quantity of Aggregate

- Volume by m^3 = 0.0311 * (1.5/3.25) * 1500

= 21.53kg

Water to cement ratio (30%)

- Water = 0.32 * 13.8kg = 4.416kg

Having 0.32% W/C ratio make the slump test 5 cm and it's a better result.

Summary of test results

Specimen no	Dimensions (cm)			Area (cm^2)	Failure Load (KN)	Compressive strength (Mpa)
	L	W	H			
1	15	15	15	225	640.4	28.46
2	15	15	15	225	632.3	28.10
3	15	15	15	225	636.3	28.28

Table 4. 3:- test result of trial mix for day 4.

Fig 4. 1:- sample trial mixes and there result on compressive strength.

Cylindrical test specimens

Fig 4. 2:- cylindrical test specimens.

4.2:- Compressive strength of concrete with various percentage of jute fiber.

Compressive strength test, mechanical test measuring the maximum amount of compressive load a material can bear before fracturing. The test piece, usually in the form of cube, prism, or cylinder is compressed between the platens of a compressional- testing machine by a gradually applying load.

Fig 4. 3:- compressive strength measuring apparatus from our lab.

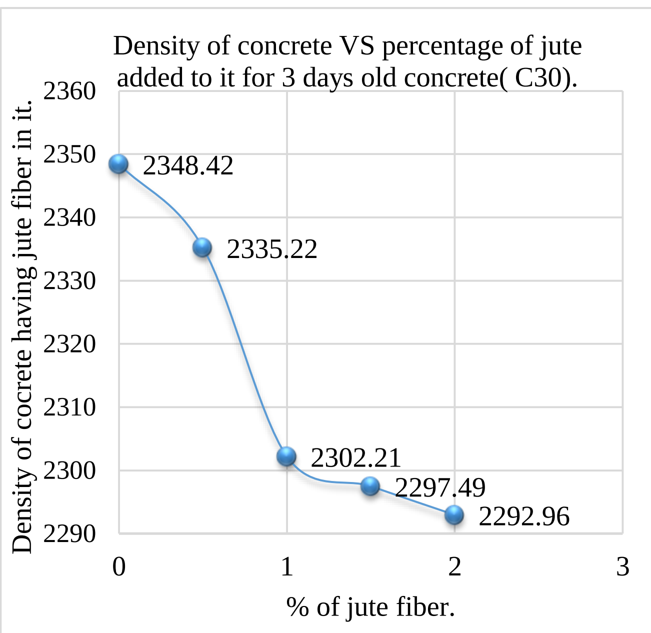
3 day age concrete.

In the construction process, it is always important to know the concrete compressive strength. The recommended procedure to ensure the concrete strength is to perform cylinder test. Test result of concrete cylinder at 28th day, represents the characteristic strength of the concrete that has been prepared and cast to form the concrete work. Usually two concrete cylinders (specimen) are cast for each day’s representative strength test. The 3-days or 7-days tests are done to assess the early gain of concrete strength. However, 28-days tests are mandatory as per design/construction code requirements.

If due to some experimental error in mix design the test results fail to achieve the designed strength, then repetition of the entire process becomes mandatory, which can be costly and time consuming. For every failure, it is necessary to wait at least 28 days, thus the need for an easy and suitable method for estimating the strength at an early age of concrete is being felt all the time. That’s why from different experimental investigation, it’s seen that an approximation of 40% of its compressive strength is gained at early age of 3 day. So we can conduct 3 day compression test and estimate its full strength achievement.

Specimen ID	Dimensions (mm)		Area (mm^2)	Weight (Kg)	Volume m3	Density (kg/m3)	Failure Load (KN)	Compressive strength (MPa)	% of jute fiber
	D (mm)	L (mm)							
PCC(3)	150	300	17671.5	12.45	0.0053	2348.42	328.4	18.58	0
0.5%C(3)	150	300	17671.5	12.38	0.0053	2335.22	436.1	24.68	0.5
1%C(3)	150	300	17671.5	12.205	0.0053	2302.21	356.6	20.18	1
1.5%C(3)	150	300	17671.5	12.18	0.0053	2297.49	418.6	23.69	1.5
2%C(3)	150	300	17671.5	12.156	0.0053	2292.96	235.21	13.31	2

Table 4. 4:- Compressive strength of concrete with various percentage of jute fiber with 3 day age.



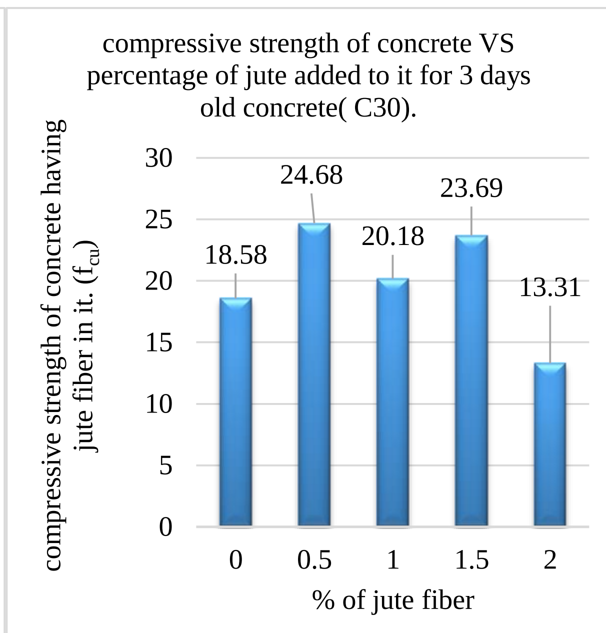


Fig 4. 4:- Density and Compressive strength of concrete with various amount of jute fiber for 3 days old concrete (C30) which is provided for compression test.

7 day age concrete.

It's clear that concrete gain its strength rapidly in the initial days after casting, i.e. 65% in only 7 days. When, its strength have reached 90% in 14 days, still concrete continues to gain strength after that period, but the rate of gain in compressive strength is very less compared to that of early stages in the first two weeks.

After 14 days of casting, concrete gain only 9% in next 14 days. So, rate of gain of strength decrease. Because of that, it's mandatory to cross check its behavior in the early stage.

Specimen ID	Dimensions (mm)		Area (mm^2)	Weight (Kg)	Volume m3	Density (kg/m3)	Failure Load (KN)	Compressive strength (MPa)	% of jute fiber
	D (mm)	L (mm)							
PCC(7)	150	300	17671.5	12.51	0.0053	2359.74	365.99	20.7	0
0.5%C(7)	150	300	17671.5	12.505	0.0053	2358.79	417.80	23.64	0.5
1%C(7)	150	300	17671.5	12.33	0.0053	2325.78	442.60	25.04	1
1.5%C(7)	150	300	17671.5	12.29	0.0053	2318.24	427.65	24.2	1.5
2%C(7)	150	300	17671.5	12.225	0.0053	2305.98	237.68	13.45	2

Table 4. 5:- Compressive strength of concrete with various percentage of jute fiber with 7 day age.

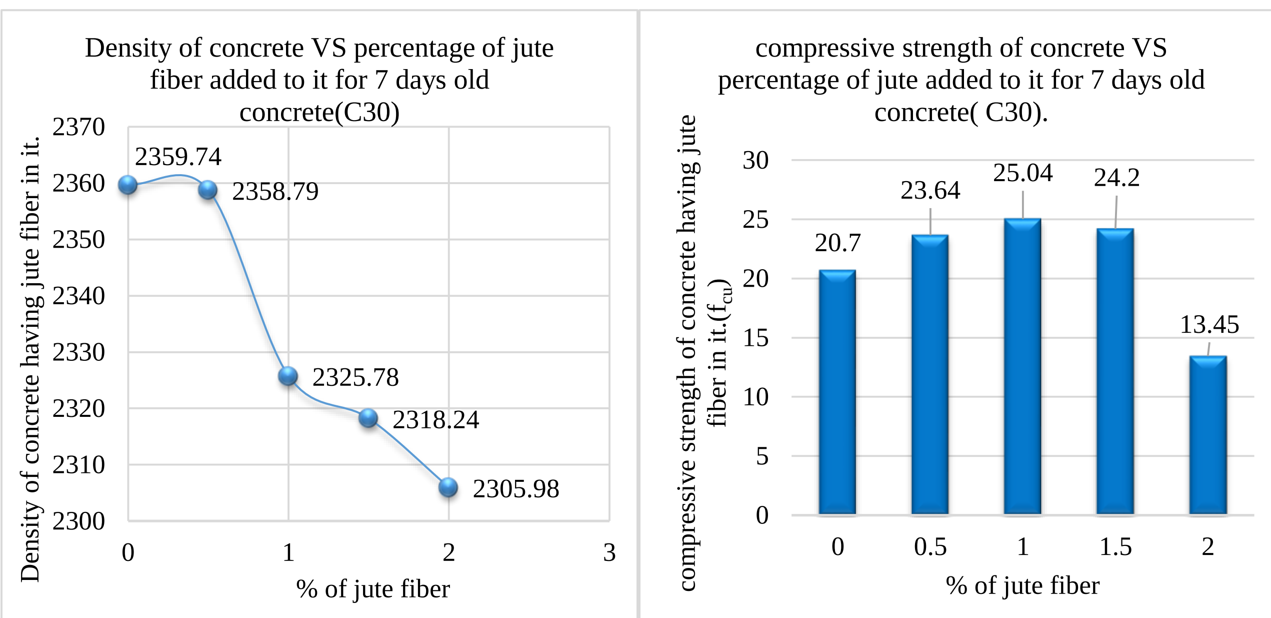


Fig 4. 5:- Density and Compressive strength of concrete with various amount of jute fiber for 3 days old concrete (C30) which is provided for compression test.

28 day age concrete.

The design strength of the concrete normally represents its 28th day strength. In case of construction work 28 days is considerable time to wait for the test results of concrete strength, while it also represents the quality control process of concrete mixing, placing, proper curing etc.

I have no clear idea up to when concrete gains its full strength, 1 year or 2 year, but it's assumed that the concrete may gain its final strength after 1 year. So, since the concrete strength is 99% at 28 days, it's almost close to its final strength, thus we rely upon the result of compressive strength test of 28 day and use this strength as the base for our design and evaluation.

Specimen ID	Dimensions (mm)		Area (mm^2)	Weight (Kg)	Volume m3	Density (kg/m3)	Failure Load (KN)	Compre strength (MPa)	% of jute fiber
	D	L							
PCC(28)	150	300	17671.5	12.68	0.0053	2391.80	517.95	29.31	0
0.5%C(28	150	300	17671.5	12.6	0.0053	2376.71	396.6	22.43	0.5
1%C(28)	150	300	17671.5	12.344	0.0053	2328.43	555.8	31.45	1
1.5%C(28	150	300	17671.5	12.255	0.0053	2311.64	456.2	25.81	1.5
2%C(28)	150	300	17671.5	12.2	0.0053	2301.26	225.4	14.45	2

Table 4. 6:- Compressive strength of concrete with various percentage of jute fiber with 28 day age.

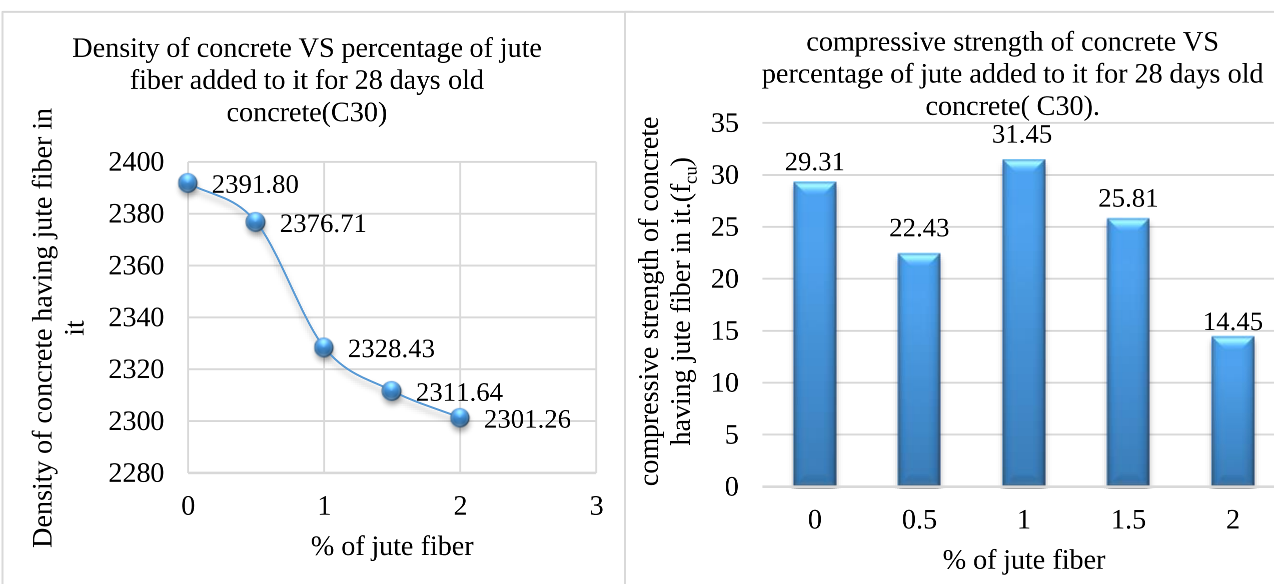


Fig 4. 6:- Density and Compressive strength of concrete with various amount of jute fiber for 28 days old concrete (C30) which is provided for compression test.

4.3:- Splitting tensile strength of cylindrical concrete specimens with various percentage of jute fiber. Tensile strength is an important property of concrete. Because concrete structures are highly vulnerable to tensile cracking due to various kinds of effects and applied loading itself. It's the standard test, to determine the tensile strength of concrete in an indirect way.

Calculating splitting tensile strength of the specimen as follows.

Ϭ = (2 * P) / (Π * L * D)

Ϭ = splitting tensile strength, Mpa

P = maximum applied load indicated by test machine, KN

L = length of specimen (mm)

D = diameter of cylindrical specimen (mm)

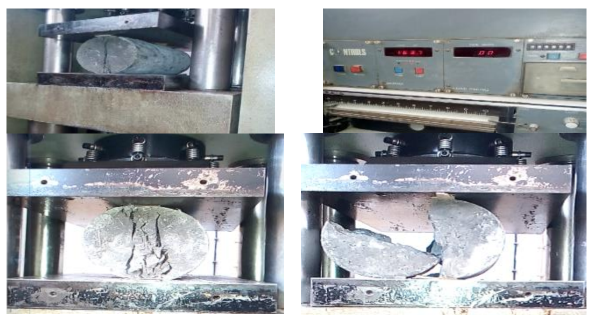


Fig 4. 7:- tensile strength machine from our lab.

3 day age concrete.

Sample ID	Dimensions (mm)		Area (mm^2)	Weight (Kg)	Volume m3	Density (kg/m3)	(P) (KN)	Tensile strength (Ϭ) (MPa)	% of jute fiber
	D	L							
PCT(3)	150	300	17671.5	12.515	0.0053	2360.68	168.4	2.38	0
0.5%T(3)	150	300	17671.5	12.5	0.0053	2357.85	163.7	2.32	0.5
1%T(3)	150	300	17671.5	12.48	0.0053	2354.08	127.7	1.81	1
1.5%T(3)	150	300	17671.5	12.39	0.0053	2337.10	208.7	2.95	1.5
2%T(3)	150	300	17671.5	12.33	0.0053	2325.78	182.2	2.58	2

Table 4. 7:- tensile strength of concrete with various percentage of jute fiber with 3 day age.

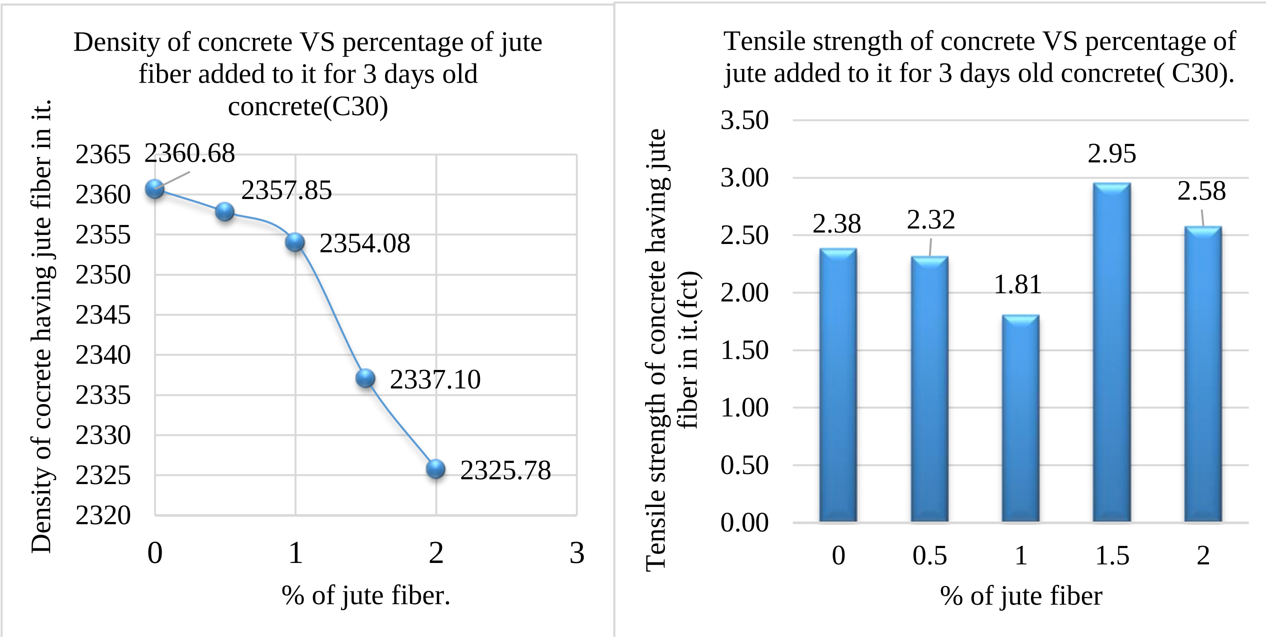


Fig 4. 8:- Density and Tensile strength of concrete with various amount of jute fiber for 3 days old concrete (C30) which is provided for splitting test.

7 day age concrete.

Split tensile strength is an indirect method to determine the tensile strength of concrete. The C30 grade concrete is prepared and placed in the mold (cylinder) of size 150mm x 300mm. A layer of oil or grease is applied on the walls of the mold. The concrete is placed in the mold and vibrate using electrical vibrator.

Sample ID	Dimensions (mm)		Area (mm^2)	Weight (Kg)	Volume m3	Density (kg/m3)	(P) (KN)	Tensile strength (Ϭ) (MPa)	% of jute fiber
	D (mm)	L (mm)							
PCT(7)	150	300	17671.5	12.51	0.0053	2359.74	200.3	2.83	0
0.5%T(7)	150	300	17671.5	12.54	0.0053	2365.40	136.2	1.93	0.5
1%T(7)	150	300	17671.5	12.425	0.0053	2343.70	168.6	2.39	1
1.5%T(7)	150	300	17671.5	12.33	0.0053	2325.78	198	2.80	1.5
2%T(7)	150	300	17671.5	12.305	0.0053	2321.07	151.4	2.14	2

Table 4. 8:- tensile strength of concrete with various percentage of jute fiber with 7 day age.

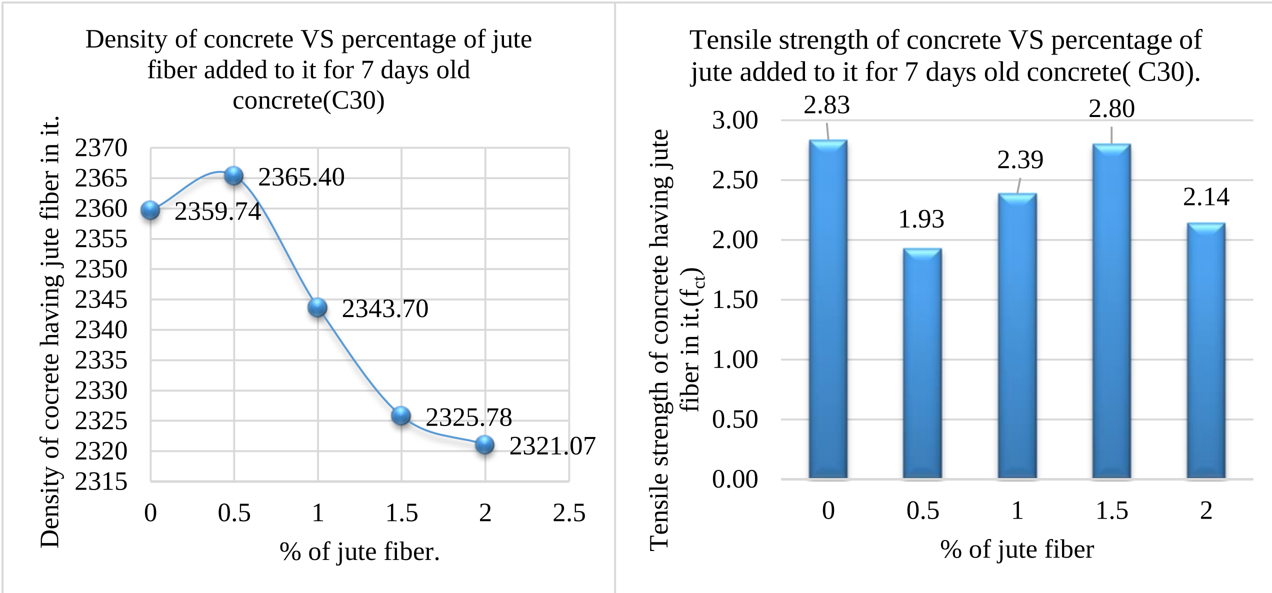


Fig 4. 9.:- Density and Tensile strength of concrete with various amount of jute fiber for 7 days old concrete (C30) which is provided for splitting test.

28 day age concrete.

Splitting tensile tests were also conducted on specimens of each concrete at 28 days like to the procedures stated earlier for 3 and 7 days specimens. The splitting tensile strength of concrete was also measured at 28 days. Fig. 4.12 show the individual strengths of four specimens per percentage of jute fiber added to it at ages of 28. The figure demonstrate a strength reach its peak point while the jute fiber have 0.5 and 1.5% of volume of concrete.

Sample ID	Dimensions (mm)		Area (mm^2)	Weight (Kg)	Volume m3	Density (kg/m3)	(P) (KN)	Tensile strength (Ϭ) (MPa)	% of jute fiber
	D	L							
PCT(28)	150	300	17671.5	12.68	0.0053	2391.80	188.6	2.67	0
0.5%T(28)	150	300	17671.5	12.555	0.0053	2368.23	233.9	3.31	0.5
1%T(28)	150	300	17671.5	12.365	0.0053	2332.39	213.3	3.02	1
1.5%T(28)	150	300	17671.5	12.31	0.0053	2322.01	223.7	3.16	1.5
2%T(28)	150	300	17671.5	12.23	0.0053	2306.92	188	2.66	2

Table 4. 9:- tensile strength of concrete with various percentage of jute fiber with 28 day age.

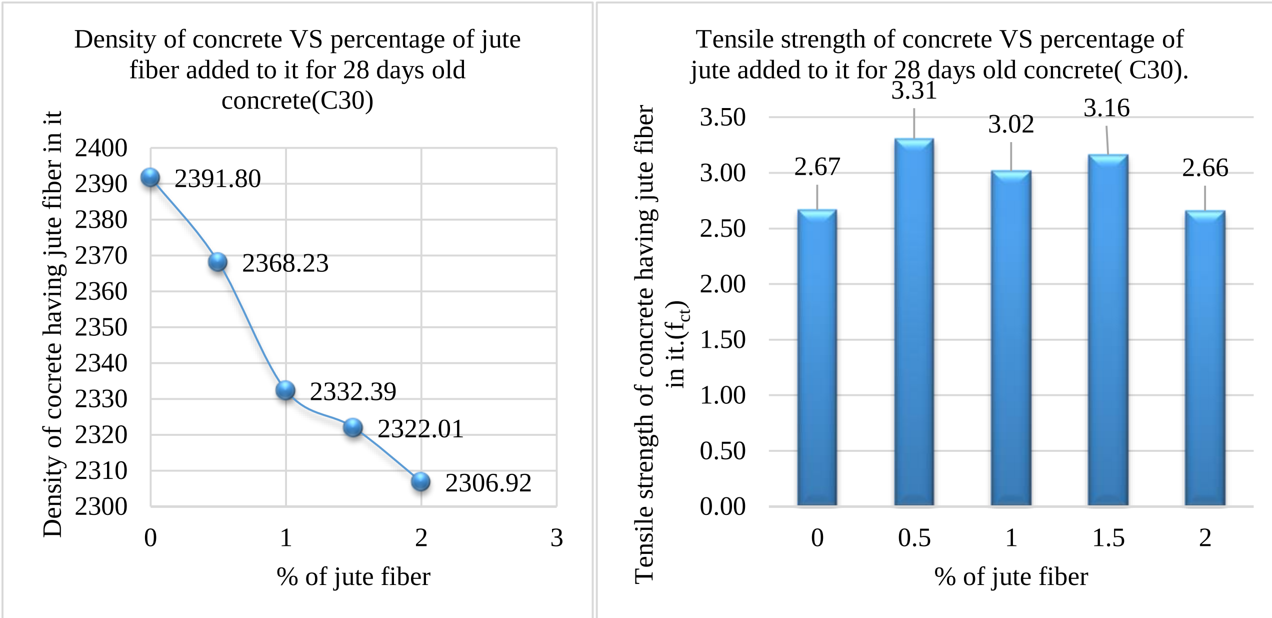


Fig 4. 10.:- Density and Tensile strength of concrete with various amount of jute fiber for 28 days old concrete (C30) which is provided for splitting test.

4.4:- Flexural strength of Rectangular plane concrete specimens with various percentage of jute fiber.

It is the ability of a beam or slab to resist failure in bending. It is measured by loading unreinforced 100*100 square concrete beams with a span five times the width which is 500mm. The flexural strength is expressed as “Modulus of Rupture” (MR) in MPa. Flexural Strength is about 12 to 20% of compressive strength [ASTM C78]. However, the best correlation for specific materials is obtained by laboratory tests.

Fig 4. 11:- 100*100*500 mm beam specimens for flexural strength test.

Two and one- point loading

Half the load is applied to at each third of the span length.

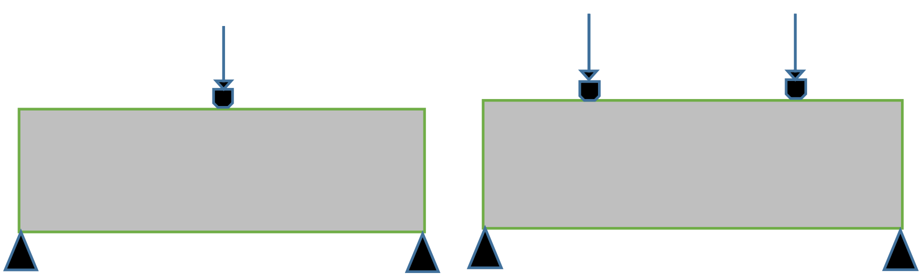


Fig 4. 12:- Beam having two and one point loading.

WHAT ARE THE PROBLEMS WITH FLEXURE?

Flexural tests are extremely sensitive to specimen preparation, handling, and curing procedure. Beam specimens are very heavy, and allowing a beam to dry will yield lower strengths. Beams must be cured in a standard manner, and tested while saturated surface dry. A short period of drying can produce a sharp drop in flexural strength.

The concrete industry and inspection agencies are much more familiar with traditional cylinder compression tests for control and acceptance of concrete. Flexure can be used for design purposes, but the corresponding compressive strength should be used to and accept the concrete. Any time trial batches are made, both flexural and compressive tests should be made so that a correlation can be developed for field control.

- In this study it is conducted using two point loading.

7 day concrete

sample ID	Dimension			Area (mm^2)	Weight (kg)	Volume (m^3)	Density (kg/m^3)
	B	H	L				
	mm	mm	mm				
PCF(7)	100	100	500	10000	11.88	0.005	2376
0.5%F(7)	100	100	500	10000	11.745	0.005	2349
1%F(7)	100	100	500	10000	11.57	0.005	2314
1.5%F(7)	100	100	500	10000	11.615	0.005	2323
2%F(7)	100	100	500	10000	11.535	0.005	2307

Crack width (mm)	Failure point from edge (cm)	Flexural load applied from machine (P)	Flexural strength (Ϭ)	Load Rating (Mpa/s)	% of jute fiber added to concrete
brittle failure	22	6.93	3.12	0.2	0
2	19.5	9.51	4.28	0.2	0.5
1	23	6.98	3.14	0.2	1
0.6	15.5	9.62	4.33	0.2	1.5
1	34	9.97	4.49	0.2	2

Table 4. 10:- Flexural strength plain of concrete with various percentage of jute fiber with 7 day age.

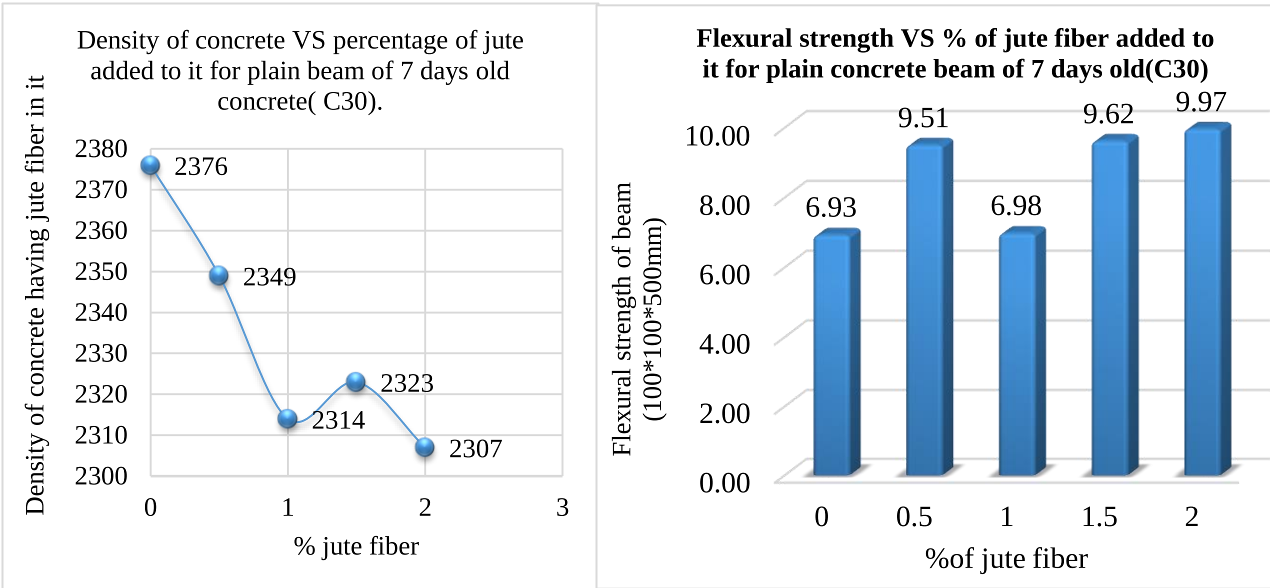


Fig 4. 13:- Density and Flexural strength of plane concrete beam having different percentage of jute fiber.

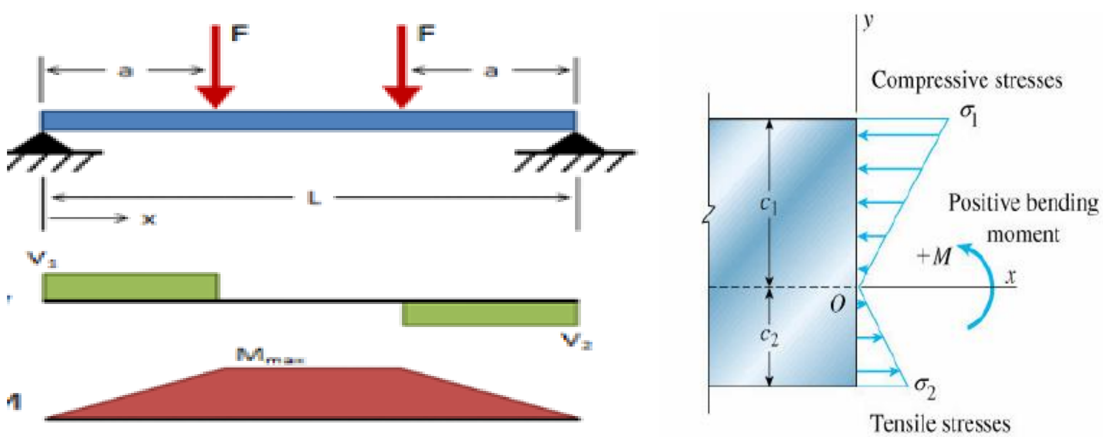


Fig 4. 14:- Shear force and Bending moment diagram for two point loading with respect to internal stress for plain beam.

Where F = (P/2) and the moment M= F*a = (p/2)*a

- Moment of inertia for rectangular section, I = $(b*h^3)/12$
- The stress in the beam is, Ϭ = (M*y)/I, where y is the centroid of cross section.

For those constant parameters of b = 100mm, h = 100mm and a = (500/3) mm and substituting all constants.

$y = (\sigma * b * h^3)/ (6000 * P * a)$

The maximum tensile and compressive stresses occur at the points located farthest from the N.A.

Failure load P(KN)	Centroid point measured from top C_1(mm)	Centroid point measured from bottom C_2(mm)	Compressive stress σ_1(Mpa)	Tensile stress σ_2(Mpa)
6.93	45.035	54.965	3.12	3.808
9.51	45.015	54.985	4.28	5.228
6.98	45.011	54.989	3.14	3.836
9.62	45.040	54.960	4.33	5.287
9.97	45.049	54.951	4.49	5.477

Table 4. 11:- Failure stress emerged in the beam.

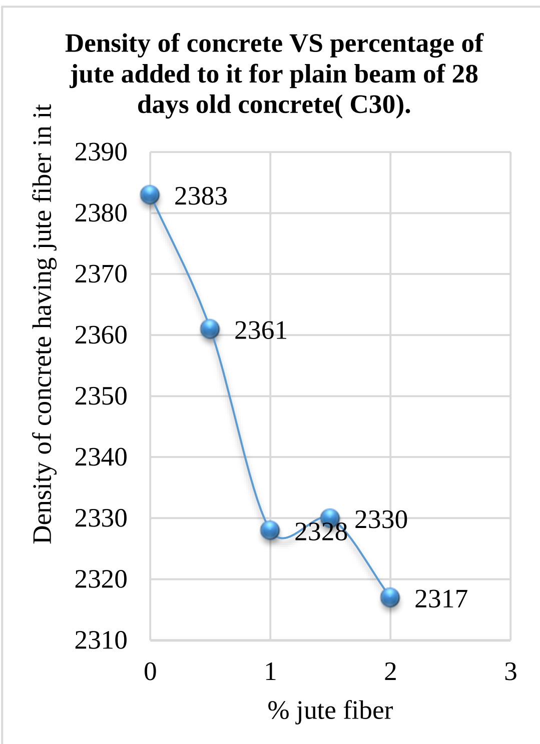
28 day concrete

Fig 4. 15:- Modified test undertaken for flexure using universal test machine and test specimen after failure.

sample ID	Dimension			Area (mm^2)	Weight (kg)	Volume (m^3)	Density (kg/m^3)
	B	H	L				
	mm	mm	mm				
PCF(28)	100	100	500	10000	11.915	0.005	2383
0.5%F(28)	100	100	500	10000	11.805	0.005	2361
1%F(28)	100	100	500	10000	11.64	0.005	2328
1.5%F(28)	100	100	500	10000	11.65	0.005	2330
2%F(28)	100	100	500	10000	11.585	0.005	2317

Crack width (mm)	Failure point from edge (cm)	Crack load P(KN)	Failure load P(KN)	% of jute fiber added to concrete
brittle failure	25	5.38	5.38	0
4	18.5	6.83	6.93	0.5
2	25	5.63	5.63	1
2	20.5	9.23	9.23	1.5
1.5	17.5	9.53	9.73	2

Table 4. 12:- Flexural strength of plain concrete with various percentage of jute fiber with 28 day age.



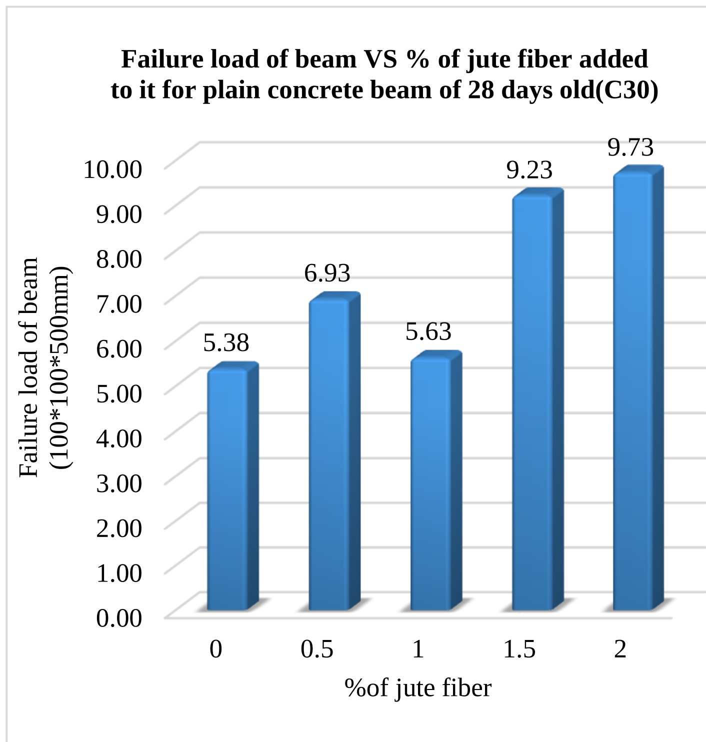


Fig 4. 16:- Density and Failure load of plane concrete beam having different percentage of jute fiber for 28 days old concrete.

4.5:- Flexural strength of Rectangular Reinforced concrete specimens with various percentage of jute fiber.

Beams

Longitudinal reinforcement

Minimum and maximum reinforcement areas

(1) The area of longitudinal tension reinforcement should not be taken as less than $A_{s,\,min}$.

The recommended value is given in the following equation:-

- $A_{s,\,min} = 0.26*(f_{ctm}/f_{yk})*b_t*d \geq 0.0013\ b_t\ d$……………… EBCS EN 1992-1-1:2013 (9.1N)

  Where:

  b_t = denotes the mean width of the tension zone.

- $\rho_{min} = 0.26*(f_{ctm}/f_{yk})$

  $= 0.26*\ (2.6/300)$

  $= \underline{0.0022}$

- $f_{ctm} = \underline{2.6}$…………………… Table 3.1of EBCS EN 1992-1-1:2013 (9.1N)

- $\rho_{max} = \underline{0.04}$………………………EBCS 2 (7.12)

Taking 2ϕ10 positive reinforcement for the beam

- $\rho_{actual} = A_{s,\,actual}/A_C = \underline{0.0157}$

So that, $\rho_{min} \leq \rho_{actual} \leq \rho_{max}$……………OK!!!!!!

Shear reinforcement

(2)The maximum longitudinal spacing between shear assemblies should not exceed

- $S_{max} = 0.75d\ (1 + \cot \alpha)$……………………………… EBCS EN 1992-1-1:2013 (9.6N)

  $= 0.75*100*(1+\cot 90^0)$

  $= 37.5mm \approx \underline{40mm}$

Where α is the inclination of the shear reinforcement to the longitudinal axis of the beam.

- $\rho_{w,\,min} =(\ 0.08(\sqrt{f_{ck}})/\ f_{yk})$………………………………. EBCS EN 1992-1-1:2013 (9.5N)

  $= 0.08*\sqrt{25}/300$

  $= \underline{0.0013}$

Taking ϕ8 c/c 40mm reinforcement for stirrup.

- $A_{sw} = (l/s) * (P * d^2 /4) = (500/40) * (P * 8^2/4)$

  $= 653.45mm^2$

(3) The ratio of shear reinforcement is given by Expression (9.4):

- $\rho_w = A_{sw} / (s*b_w* \sin \alpha)$………………………………. EBCS EN 1992-1-1:2013 (9.4N)

  Where:

  ρ_w = is the shear reinforcement ratio

  ρ_w should not be less than $\rho_{w, min.}$

  A_{sw} = the area of shear reinforcement within length S

  S = the spacing of the shear reinforcement measured along the longitudinal axis of the member

  b_w = the breadth of the web of the member

  α = the angle between shear reinforcement and the longitudinal axis.

- $\rho_{actual} = A_{sw} / (s*b_w* \sin \alpha)$

  $= 653.45mm^2/ (500mm*100mm*1)$

  $= 0.013$ ……. Since, $\rho_{w, min} \leq \rho_{actual}$

  $0.0013 \leq 0.013$ ………OK!!!!!

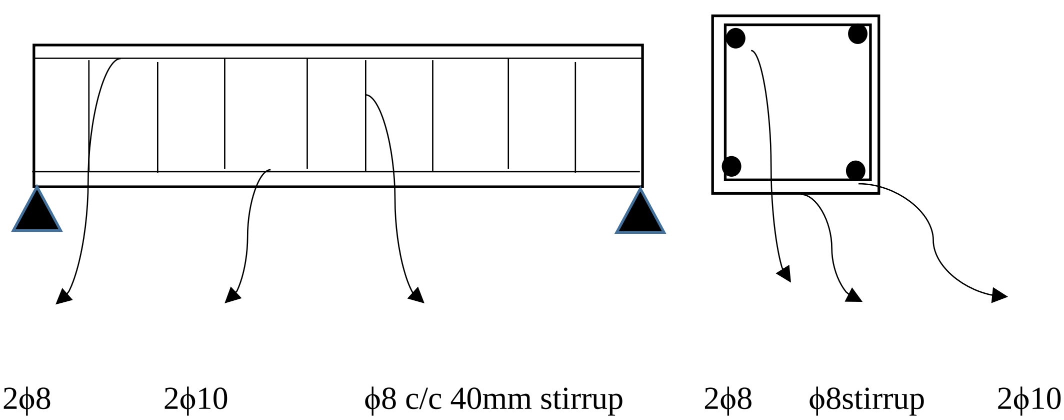


Fig 4. 17:- Cross sectional area and longitudinal & transverse Reinforcement of beam for Flexure test.

21 days Reinforced Concrete.

Fig 4. 18:- Modified test undertaken for flexure using universal test machine and test specimen after failure for 21 days old RC beam.

sample ID	Dimension			Area (mm^2)	Weight (kg)	Volume (m^3)	Density (kg/m^3)
	B	H	L				
	mm	mm	mm				
RPCF(21)	100	100	500	10000	12.775	0.005	2555
R0.5%F(21)	100	100	500	10000	12.815	0.005	2563
R1%F(21)	100	100	500	10000	12.815	0.005	2563
R1.5%F(21)	100	100	500	10000	12.88	0.005	2576
R2%F(21)	100	100	500	10000	12.91	0.005	2582

Crack width (mm)	Failure point from edge (cm)	Crack load P(KN)	Failure load P(KN)	% of jute fiber added to concrete
1	23	28.64	31.73	0
Failure emerged from support for all RC beams	3.5	28.53	30.83	0.5
	3	23.33	28.22	1
	4	29.95	34.65	1.5
	3.5	30.73	35.03	2

Table 4. 13:- Flexural strength of Reinforced concrete with various percentage of jute fiber with 21 day age.

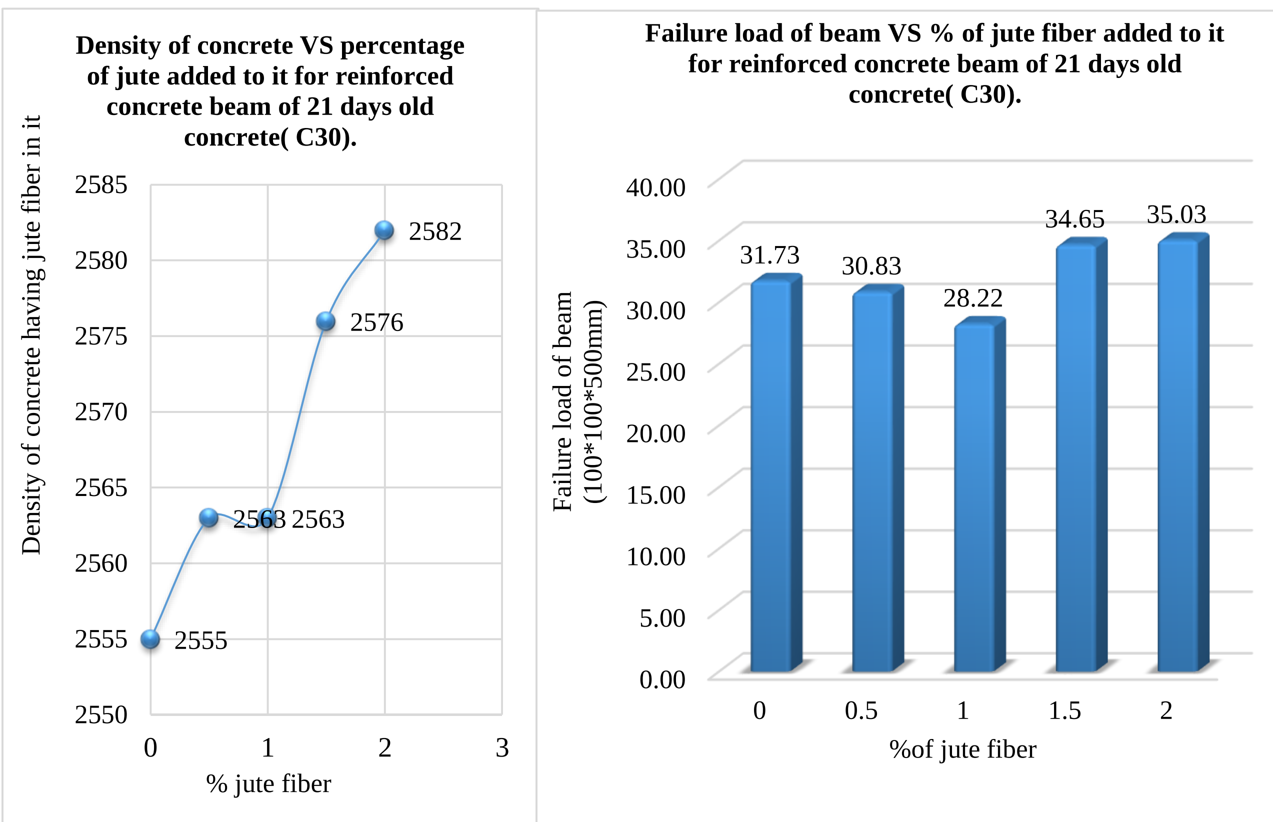


Fig 4. 19:- Density and Failure load of Reinforced concrete beam having different percentage of jute fiber for 21 days old concrete.

28 days Reinforced Concrete.

sample ID	Dimension			Area (mm^2)	Weight (kg)	Volume (m^3)	Density (kg/m^3)
	B	H	L				
	mm	mm	mm				
RPCF(28)	100	100	500	10000	12.56	0.005	2512
R0.5%F(28)	100	100	500	10000	12.43	0.005	2486
R1%F(28)	100	100	500	10000	12.12	0.005	2424
R1.5%F(28)	100	100	500	10000	12.04	0.005	2408
R2%F(28)	100	100	500	10000	11.72	0.005	2344

Crack width (mm)	Failure point from edge (cm)	Crack load P(KN)	Failure load P(KN)	% of jute fiber added to concrete
	24.5	46.30	47.40	0
Failure emerged at support for all RC beams	0 – 4 cm	43.10	46.50	0.5
		39.10	47.00	1
		46.20	47.10	1.5
		46.80	47.90	2

Table 4. 14:- Flexural strength of Reinforced concrete with various percentage of jute fiber with 28 day age.

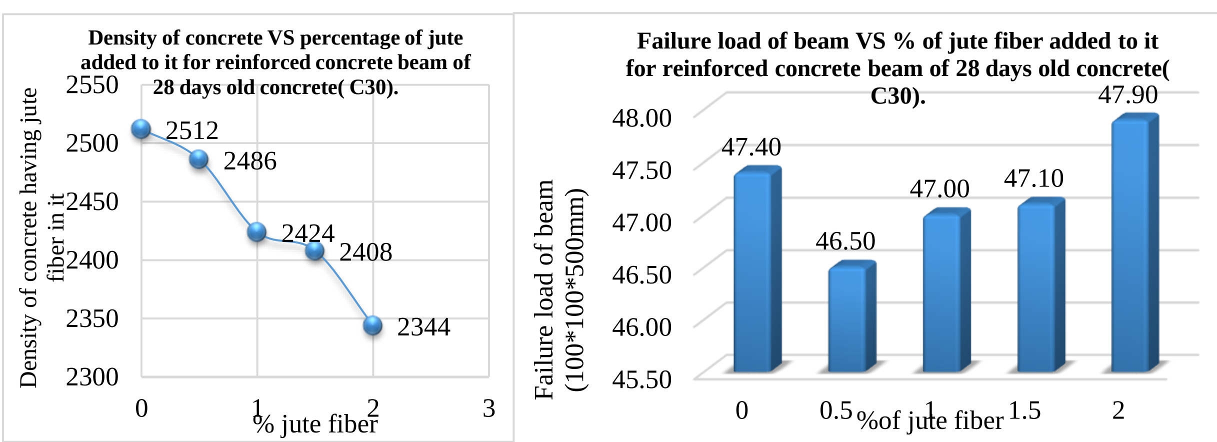


Fig 4. 20:- Density and Failure load of Reinforced concrete beam having different percentage of jute fiber for 28 days old concrete.

CHAPTER 5

CONCLUSION AND RECOMMENDAION.

Concrete with jute fiber is an aspiring step towards the sustainable development in Ethiopia where in regions that jute are abundantly cultivated. In the experimental investigations conducted in the study, it was found that the addition of jute fiber contributes enriched results for mechanical properties of concrete composites for a particular length and content of fiber. More specifically, compressive, flexural, and tensile strength are found to enhance significantly for volume content of 1.5% and the fiber cut length is 15cm. However, with different fiber length and content, the mechanical properties should have to be further investigate.

- It is clearly seen that there is an early strength achievement, on sample specimens provided for test, beyond the expected outcome.
- It's clearly seen that all cylindrical specimens with various amount jute fiber achieve their 70-85% of strength within a week. Exclusive to that of concrete with 2% jute fiber.
- Generally it can be concluded that adding jute fiber in concrete alter the compressive strength of concrete.

It can be stated that the remarkable enrichment of compressive strength is observed only with 1 % volumetric content; however, the 2% volumetric content causes the maximum strength loss of concrete composites.

EBCS 1995 and EBCS EN 1992-1-1:2013 are more conservative, on tensile strength of concrete , than the actual strength.

- Convenient, improved, consistent and relatively good result for tensile strength of concrete is observed while we add 1.5% of jute fiber for all examined days.
- 90% density of concrete is decrease when percentage of jute fiber added to it increase. Almost all of the specimens weight show decrement when more and more jute fiber put into it.
- Unit weight of plain concrete ranges from 22.9 – 23.9 KN/m^3 and for Reinforced concrete beams it ranges from 23.44 – 25.82 KN/m^3. But theoretically it's stated that unit weight of plain and reinforced concrete is considered as 24 and 25 KN/m^3 respectively.
- Adding jute fiber in concrete enhance the tensile strength of plain beam by shifting centroidal point up 5mm and expose majority of the cross section for tension.

- In case of plain beam having no reinforcement bar in it, remarkable enrichment of flexural strength is observed with 1.5 and 2 % volumetric content. 0 and 1% volumetric content has least amount of strength.
- In case of RC beam, remarkable enrichment of flexural strength for 21 and 28 day of is observed with 1.5 and 2 % volumetric content. 1% volumetric content has least amount of strength.
- For plane concrete without reinforcement bar and RC beams without jute fiber, it's observed that the failure mode is in flexure and remaining beams, excluding those listed above, and failed with shear. They have exposure to jute fiber which might alter the concrete property and cause them to fail through shear. So to make this beams fail in flexure it's recommended to make shear reinforcements close each other or improve the concrete property. Because the beam shall fail through flexure prior to shear.
- **Finally concrete having jute fiber of length 15cm and 1.5% of its volumetric content have the optimal result for compression, Tension as well as Flexure.**

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ANNEX A (INFORMATIVE)

A.1 Physical Property Of Fine Aggregate

Sieve (mm)	Weight Of Sieve + Sand (g)	Weight Of Sieve (g)	Mass Retained (g)	% Retained	Cumulative % passing	limits		
						20mm	10mm	W.sand
37.5						100		
19.5(20)						85-100		
14						0-70	100	
9.5(10)	625	625	0	0	100	0-25	85-100	
4.75	450	425	25	5.15	94.58		0-25	
2.36	440	390	50	10.31	**84.58**		0-5	**60-100**
1.18	460	355	105	21.65	**62.93**			**30-90**
0.6	515	325	190	39.18	**23.75**			**15-54**
0.3	405	305	100	20.62	**3.13**			**5-40**
0.15	300	285	15	3.13	0			
0.075								
pan	415	415						

Table A. 1:- particle size distribution for fine aggregate

Note 1 : linear interpolation may be used for intermediate values.

Sieve size	weight retained(g)	Cumulative weight retained (g)	Cumulative Percentage weight Retained (%)
4.75	25	25	5.15%
2.36	50	75	15.45%
1.18	105	180	37.11%
0.6	190	370	76.29%
0.3	100	470	96.9%
0.15	15	485	100%

Table A. 2:- Finess modulus for fine aggregate (sand).

DISCRIPTION			WEIGHT(g)
1.	Weight of pan + sample + water(A)	g	839.48
2.	Weight of pan + water(B)	g	531.03
3.	Weight of saturated & surface dry sample(C)	g	484.48
4.	Weight of oven dry sample(D)	g	470.1
5.	Specific Gravity of sample		

Table A. 3:- specific Gravity of fine aggregate.

Silt content of fine aggregate = ($\frac{H1}{H2}$)*100 --[A.1]
Specific gravity of fine aggregate = D/(C-(A-B)) ---[A.2]

Moisture content % of fine aggregate = ((C-D)/D)*100 --[A.3]
Finess Modulus of aggregate = (cumulative % retained)/100 ------------------------------------[A.4]
A.2 Physical Property Of coarse Aggregate

Sieve (mm)	Weight Of Sieve + Sand (g)	Weight Of Sieve (g)	Mass Retained (g)	% Retained	Cumulative % passing	limits		
						40mm	20mm	10mm
37.5	1160	1080	80	1.46	**98.54**	**95-100**	100	
19.5(20)	4425	1385	3040	55.32	**43.23**	**30-70**	85-100	
14							0-70	100
9.5(10)	2705	1165	1540	28.03	**15.2**	**10-35**	0-25	85-100
4.75	1975	1175	800	14.56	**0.64**	**0-5**		0-25
2.36								0-5
1.18								
0.6								
0.3								
0.15								
0.075								
pan	770	735	35	0.64	0			

Table A. 4:- particle size distribution for coarse aggregate.

DISCRIPTION			WEIGHT(g)
1.	Weight of pan + sample + water(A)	g	7400
2.	Weight of pan + water(B)	g	6070
3.	Weight of saturated & surface dry sample(C)	g	2080
4.	Weight of oven dry sample(D)	g	2055
5.	Specific Gravity of sample		

Table A. 5:- specific Gravity of coarse aggregate.

Row jute fiber form local market.

Fine aggregate (sand)

Physical properties of sand and coarse aggregate.

Trial test and Mix design.

Concrete mix at lab.

Cylindrical sample concrete provided at lab.

Compressive strength test.

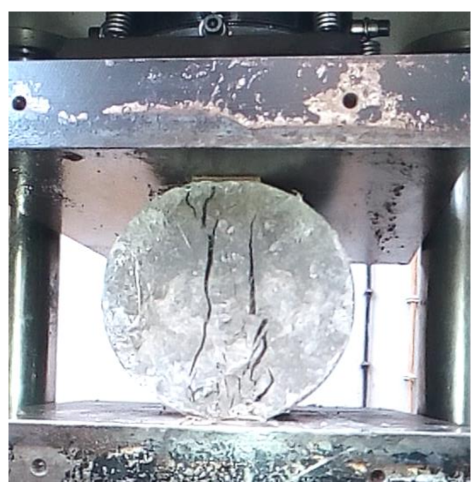
Tensile strength test (split test).

Flexural strength test without Reinforcement.

Flexural strength test with Reinforcement.

Collapse pattern of concrete through Compression.

Collapse pattern of concrete through Tension.



Collapse pattern of concrete through Flexure.

Laboratory.

Apparatus used to test compression Strength

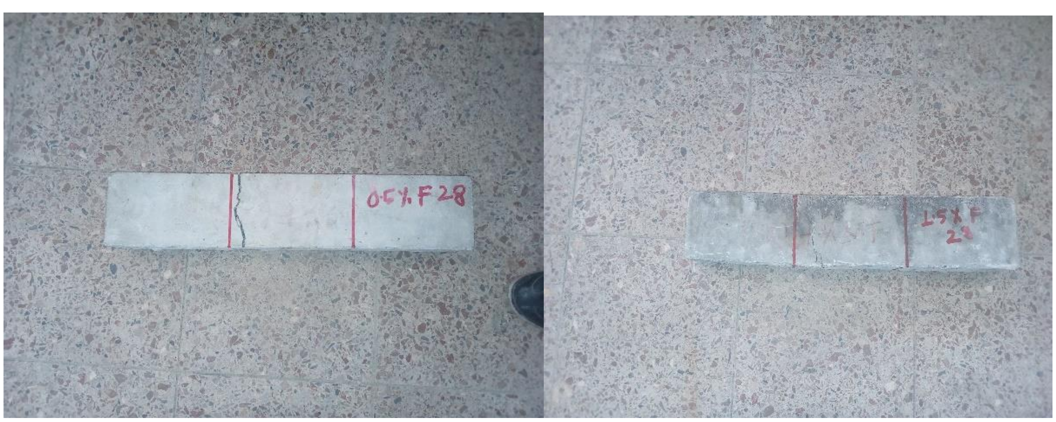
Apparatus used for tension (UTM)

Apparatus used to test Flexure.

Apparatus used to determine flexural stress on Beam.

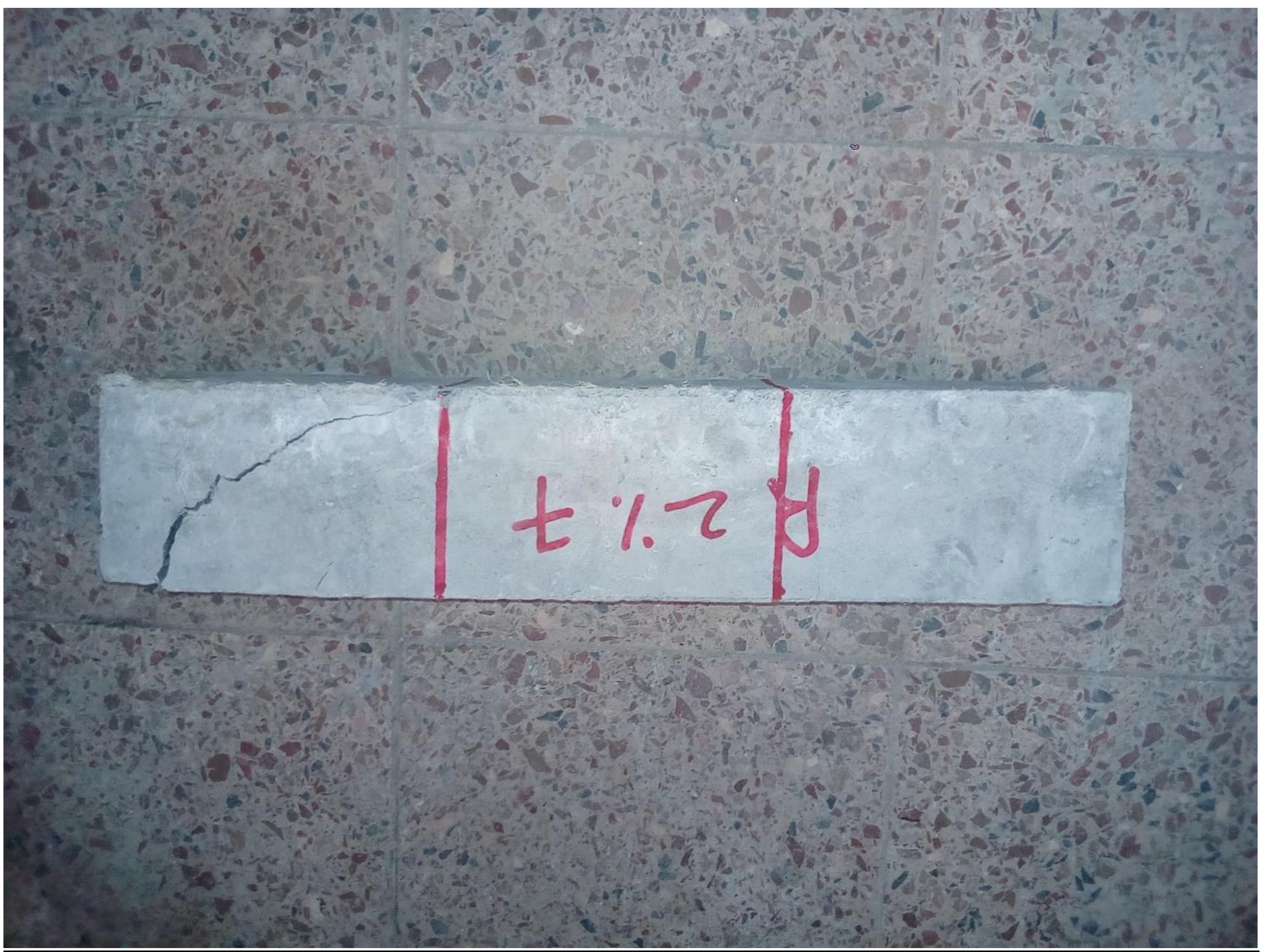
Modified technique to determine two point loading on UTM.

Crack pattern of Beam with no Reinforcement.



Sample provided for Beam with no Reinforcement.

Crack pattern of Beam with reinforcement.



Crack pattern of Beam with no reinforcement.

Sample provided for Beam with Reinforcement.


R 1.5%
7