International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 05 | May 2019 www.irjet.net p-ISSN: 2395-0072

Experimental Investigation of Natural Fiber Reinforced Concrete

Biswabhusan Parida[1], Sirajudheen Ch[2], Dr. Prof. Pravat Kumar Parhi[3]

[1]*MTech. Student, College of Engineering & Technology, Bhubaneswar, Odisha, India*
[2]*Assistant Professor, College of Engineering & Technology, Bhubaneswar, Odisha, India*
[3]*Professor, College of Engineering & Technology, Bhubaneswar,* Odisha, India

---

Abstract - *This paper investigates the effects of the addition of coconut and jute fibers on mechanical properties of fiber reinforced concrete. The properties include compressive, split & flexural strength. The influence of individual fiber percentage i.e. 0.5%, 1% & 1.5% coconut & jute fiber content by mass of cement is investigated. A total of 7 concrete mix batches were prepared. The results are compared with M-30 grade normal concrete. The addition of fibers gives lower workability of FRC. The compressive strength for the 0.5% JFRC is found to be maximum, i.e., 11.27 per cent more over the strength of normal concrete. The flexural strength for the 0.5% CFRC is found to be maximum, i.e., 60.36 per cent more over the strength of normal concrete. The split tensile strength for the 0.5% CFRC is found to be maximum, i.e., 22.62 per cent more over the strength of normal concrete. The experimental investigation has shown that the overall strength of concrete be increased by the addition of a small dose of 0.5% coconut, jute glass fiber.*

Key Words: Coconut, Jute, Mechanical Properties, M-30, Fiber Reinforced Concrete

LIST OF ABBREVIATIONS

Abbreviation	Description
CA	Coarse Aggregate
CF	Coconut Fiber
CFRC	Coconut Fiber Reinforced Concrete
FRC	Fiber Reinforced Concrete
FA	Fine Aggregate
JF	Jute Fiber
JFRC	Jute Fiber Reinforced Concrete
SP	Superplasticizer

1.INTRODUCTION

Concrete is the most widely used versatile construction material. It is present everywhere from building to bridges, dams to parking and architectural structure to the highway. Now we are in the era of concrete. Replacing with another material is difficult. It was assumed that concrete was contemplated as virtually indestructible. This thought has changed gradually. It was also believed that the useful life of concrete was determined by the proper proportion of cement, water, fine aggregate & coarse aggregate. If ordinary concrete gives better results does not mean that it cannot be improved by adding other materials. Sometimes due to certain circumstances, concrete loses its mechanical, durability properties and cannot achieve the performance. Forecasting the extent of loses is crucial. If we can add extra materials in the forms of fiber to concrete, then the results can be improved. Ductility and energy absorption capacity can be enhanced by incorporating fibers in concrete (ACI Committee 544, 1996).

There are various limitations of concrete, but the main limitations of concrete in terms of strength are low tensile strength, flexural strength, reduced resistance to opening of crack & its propagation. Fibers are reinforcing material which possesses various properties. The distribution of discrete fibers plays a vital role in the development of concrete. These are beneficial in multiple ways. They are enhancing the properties of weak, brittle building material. The enhancement of these properties includes ductility, flexural strength, tensile strength, corrosion resistance, lightweight, toughness, damage tolerance, resistance to impact and cracking, nonmagnetic properties, durability, permeability & fatigue resistance. It eliminates cracking due to plastic shrinkage & drying shrinkage.

In this experimental investigation, the properties of fiber reinforced concrete which consists of natural fibers like coconut, jute fibers were used. The aims & objective of this paper is to describe the present state of knowledge & technology of fiber reinforced concrete. In the current study convectional concrete & fiber reinforced concrete are prepared, and the response of the concrete structure to fibers are studied in terms of fresh and mechanical properties. Seven different concrete mixes (1 control + 6 FRC) were prepared.

1.1 FIBER REINFORCED CONCRETE

The fiber reinforced concrete consists of two phases, i.e. fiber phase & matrix phase. Fiber phase provides strength, in which fibers are embedded is called matrix phase. The matrix phase holds the fiber in the purposive position by giving the fiber reinforced concrete its structural integrity. The performance of the FRC depends upon the concrete & fiber. The properties of fiber depend on type, geometry, orientation, surface, distribution & concentration of fiber. The fibers in normal concrete have little or no effect on its pre cracking behavior but enhance after post cracking. Fiber is little active during the initiation of a crack but it is very active after the crack by bridging across the crack. It can transfer the force in between both faces of a crack, thus providing strength after the crack. The fibers can hold the concrete together even after considerable cracking. The fibers help concrete to become ductile after the post-cracking. This transformation of concrete from brittle material to ductile material develops other characteristics like energy absorption characteristics. These enhanced characteristics are used in the construction of pavement of airport, foundation floor in factories, earthquake resistant structures & any structures which are subjected to impact loading.

i. Coconut Fiber

Coconut fibers are available in coastal areas of tropical countries. 500,000 tonnes of coconut fibers are produced annually worldwide. There are two types of coir fibers, a brown fiber extracted from matured coconuts and white fibers extracted from immature coconuts. Brown fibers are thick, strong and have high abrasion resistance. White fibers are smoother and finer, but also weaker. The fiber is abundant, non-toxic, low density and low cost. These fibers are moth proof and resistant to fungi, rot. It provides excellent insulation against temperature & sound, flame-retardant, unaffected by moisture and dampness.

ii. Jute Fiber

Jute is environmentally friendly. These plants are easy to grow. It has a high yield value per acre. Single jute fiber is a composite composed mainly of cellulose, hemicelluloses, and lignin with minor amounts of protein, extractives, and inorganics.

1.2 LITERATURE REVIEW

Mehran Khan and Majid Ali (2018) in their paper entitled "Effect of superplasticizer on the properties of medium strength concrete (MSC) prepared with coconut fiber" have studied compressive, flexural, splitting-tensile, modulus of elasticity, absorbed energy, toughness indexes, stress-strain curves, load-deflection curves, and load-time curves. They used coconut fiber with a length of 5 cm and the fiber content of 2% and different super plasticizer content, i.e., 0%, 0.5%, 1%, and 1.5%, by mass of cement. The mix design ratio of MSCFRC is 1:2:2 (cement: sand: aggregate) with a water-cement ratio of 0.50. The optimized silica fume content for MSCFRC was 15%, by mass of cement. From the experiment, they have found that the CFRC with 15% silica fume content, 2% coconut fiber content, and 1% superplasticizer content, by cement mass, have improved mechanical properties.

Noor Md. et al. (2012) in their paper entitled "The Use of Coconut Fiber in the Production of Structural Lightweight Concrete" have studied physical and mechanical characteristics of concrete made using chopped coconut fibers incorporating different volume percentage of fibers 1, 3, 5 & 7 subjected to static loading. Compressive strength of the concrete reduces as the percentage of coconut fiber is increased. It had an optimum set of mechanical properties at 3% fiber volume as compared to others. CFRC has shown less no of crack development & crack width.

Mohammad S. Islam and Syed Ju Ahmed (2018) in their paper entitled "Influence of jute fiber on concrete properties" have studied jute fibers of two different lengths of 10 mm and 20 mm and four different percentage of 0.00%, 0.25%, 0.50%, and 1.00%. The slump of fresh concrete decreased with an increase of jute fiber content in concrete. 0.25% of jute fiber had a positive impact on the compressive strength of concrete. The experimental results revealed that the addition of 0.50% jute fiber had an adverse impact on the fresh properties of concrete. A smaller dosage (0.25%) of jute fiber showed a positive influence on the hardened properties of concrete.

Mohammad Zakaria et al. (2016) in their paper entitled "Scope of using jute fiber for the reinforcement of concrete material" have studied compressive, flexural, and tensile strengths of Jute Fiber Reinforced Concrete Composites (JFRCC). They used jute fiber with four different cut lengths 10, 15, 20, and 25 mm with 0, 0.1, 0.25, 0.50, and 0.75 % volume dosing and 25-mm down well-graded crushed bricks as coarse aggregate. The compressive, flexural, and tensile strength are found to increase significantly for 0.1, and 0.25 % and the fiber cut a length of 10 and 15 mm. For larger fiber length and content, the mechanical properties were found to affect adversely. The maximum increment observed for tensile strength is 35 % concerning the plain concrete.

2. EXPERIMENTAL PROGRAMME

2.1 Materials Used

Cement: Ordinary Portland cement of 53 Grade from Mahasakti cement is used. This Cement has been tested for various proportions as per IS 4031 and found to be conforming to IS 12269-2013.

Water: It is the essential ingredient of the concrete. It is free from impurities like oil, alkalinities, acids. The potable water accessible in the laboratory was used for mixing and curing of concrete.

Coarse Aggregate: Machine crushed well graded angular granite aggregate of nominal size from a local source is used. The aggregate size of 20mm down and 10mm down are used. The coarse aggregate is tested for various properties. It is confirming to IS 383-2016.

Fine Aggregate: The locally available river sand is used as fine aggregate. It is tested for different properties as per IS 383-2016.
Super Plasticizer: Sikaplast 4231 NS was used as an admixture.

Coconut Fiber: The locally available coconut fiber from a factory was used. The fiber was included at four different percentage i.e. 0%, 0.5%, 1% & 1.5%.

Jute Fiber: The locally available raw jute fiber was used. The fiber was included at four different percentage i.e. 0%, 0.5%, 1% & 1.5%.

Table 2.1 Physical Properties of cement

Sl. No	Name of test		Result
1	Fineness (m^2/kg)	Specific Surface	295
2	Specific Gravity		3.17
3	Setting Time (minutes)	Initial Setting Time	165
		Final Setting Time	240
4	Soundness Test	Le Chatelier Method (mm)	1.0
		Auto Clave (%)	0.074
5	Compressive strength (MPa)	3 days	38
		7 days	48
		28 days	60

Table 2.2 Physical Properties of Aggregate

Sl. No	Particulars	Fine Aggregate	Coarse Aggregate
1	Sieve Analysis	Zone III	Table 7 of IS 383-2016
2	Fineness Modulus	3.348	7.468
3	Specific Gravity	2.62	2.82
4	Water absorption (%)	0.9	0.2
5	Free (surface) moisture (%)	1.2	5

Table 2.3 Physical Properties of Fibers

Sl. No	Characteristics	Description of Fiber	
		Coconut	Jute
1.	Length (mm)	50-75	20-30
2.	Diameter (mm)	0.25-0.5	0.5-0.6
3.	Aspect Ratio(l/d)	150 - 200	20-30

Figure 2.1 Coconut Fiber

Figure 2.2 Jute Fiber

2.2 Mix Proportion

Mix design of M-30 concrete is based on IS 10262-2009. In FRC, the percentage of fibers by mass of cement was added to the mix and the same amount of coarse aggregate was deducted from the total.

Table 2.4 Quantity of Material per cubic meter of Concrete

Cement	413 kg/m^3
Water	165 litre/m^3
Fine aggregate	625 kg/m^3
Coarse aggregate	1320 kg/m^3
Chemical admixture	2.1 litre/m^3
Water-cement ratio	0.40

Table 2.5 Mix Designation

SL No	Fiber	Fiber Content (%)	Mix Designation
1	Control Mix	0 %	CC
2	Coconut	0.5 %	CF 0.5
3	Coconut	1 %	CF 1
4	Coconut	1.5 %	CF 1.5
5	Jute	0.5 %	JF 0.5
6	Jute	1 %	JF 1
7	Jute	1.5 %	JF 1.5

2.3 Tests on concrete

The cast specimens were tested as per standard testing procedures of IS: 516-1959.

Workability: The slump cone method is used to measure workability. It is a simple universally accepted method to detect variations in the uniformity of a mix. The test procedures are in accordance with IS 1199-1959.

Compressive strength: Cubes of 150 mm X 150 mm X 150 mm size was selected for this test. The compression test on the cubes was conducted on the digital compression testing machine of 3000 KN capacity.
Compressive stress (MPa) = load at failure (N) / surface area of the cube (mm^2)

Flexural Strength: The flexural strength is known as modulus of rupture in which maximum tensile strength in the bottom fiber is recorded. Beam specimen of size 500 mm X 100 mm X 100 mm was selected. Two-point loading was applied at the middle third of the span.
The flexural strength of beam is calculated by following formula.
$f = PL/bd^2$
where;
P = ultimate load applied (N), L = Effective length of the specimen (400 mm), b = breadth of the specimen (100 mm), d = depth of the specimen (100 mm).

Split Tensile Strength: Split tensile strength is an indirect test to determine the tensile strength of concrete. A cylinder of 150 mm diameter and 300 mm height was selected.
Split tensile strength $=2P/\pi dL$
Where; P=ultimate load (N), D=Diameter of the cylinder (150 mm), L=Length (or) height of the cylinder (300 mm).

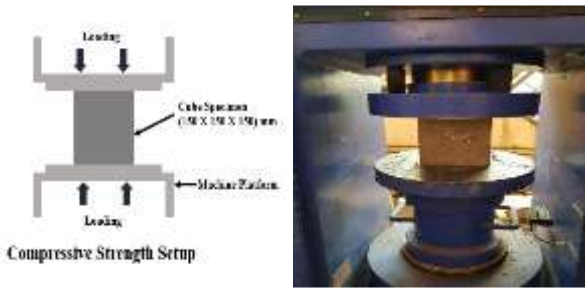

Figure 2.3 Compressive Strength of Cube

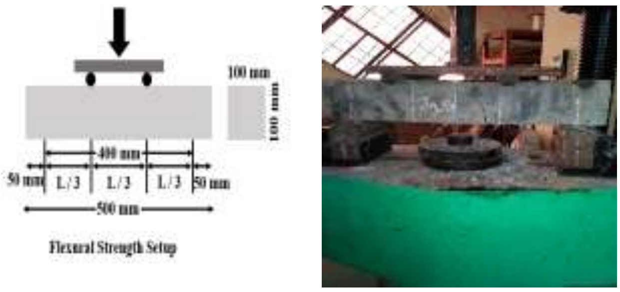

Figure 2.4 Flexural Strength of Beam

Figure 2.4 Split Tensile Strength of Cylinder

3. RESULTS & DISCUSSIONS

3.1 Workability

In all FRC, the workability of concrete significantly decreases with the increase of the fiber content. The slump value decreases rapidly when the fiber content increases beyond 1% for all FRC. At 1.5% fiber content, the reduction of workability has affected the mixing of concrete. The fiber balling effect is observed at 1.5% fiber content. The water absorption capacity increases with an increase in fiber content rate. The workability of CFRC and JFRC has remained at less medium level for 0.5% & 1% fiber content and very low workability for 1.5% fiber content.

Table 3.1 Slump values recorded & percentage drop for each mix

Mix	Slump (mm)	Percentage Drop (%)
CC	43	0
CF 0.5	32	26
CF 1	27	37
CF 1.5	19	56
JF 0.5	35	19
JF 1	29	33
JF 1.5	23	47

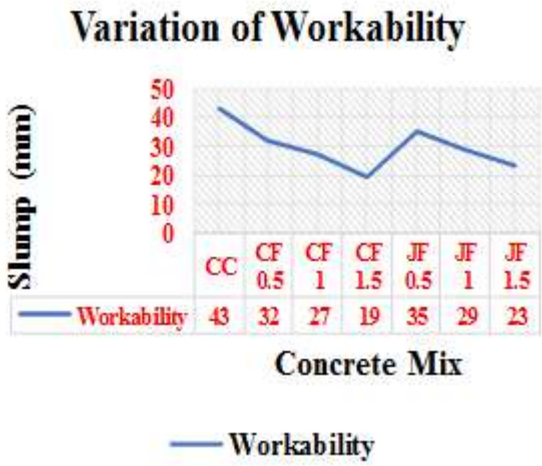

Figure-3.1 Variation of Workability

3.2 Compressive Strength (28 Day)

In all FRC strength is maximum for certain fiber content, then decreases for other fiber content. The nominal fiber content which gives maximum strength fills all the void in concrete. When fiber content is increased beyond nominal fiber, it creates more voids due to excess fiber. Some studies found that the increase of jute fiber results in high porosity in the concrete. The fiber balling results inefficacious and segregated mix. It produces honeycombed and porous concrete. As a result, compressive strength falls drastically. The discontinuous distribution of fibers creates lesser strength.

The strength CFRC is maximum at 1.5% fiber content, but it cannot be selected due to low workability & more fiber balling effect. The average compressive strength of CFRC increases by 8% compared to normal concrete. The average compressive strength of JFRC decreases by 1.5% compared to normal concrete.

Table 3.2 Variation of 28 Day Compressive Strength

Mix	Compressive Strength (MPa)	Percentage Difference (%)
CC	39.41	-

CF 0.5	43.33	9.95
CF 1	40.3	2.26
CF 1.5	44.07	11.82
JF 0.5	43.85	11.27
JF 1	37.56	- 4.69
JF 1.5	34.96	- 11.29

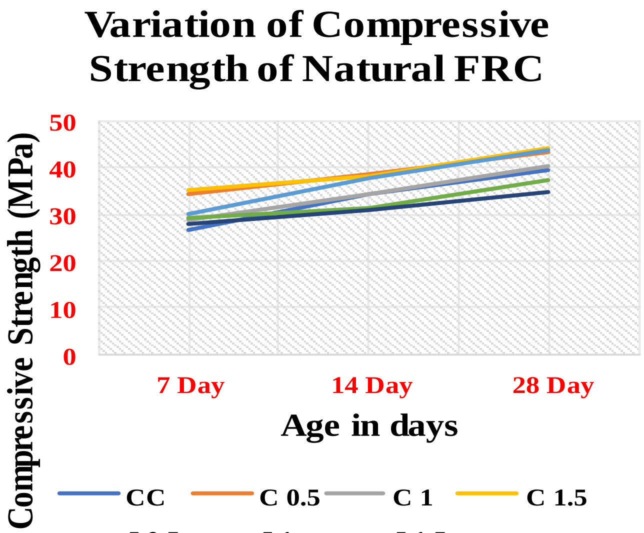

Figure-3.2 Variation of Compressive Strength of Natural FRC

3.3 Flexural Strength (28 Day)

The flexural strength is governed by the loading rate, length of fiber, shape, size, and span length of the specimen, bond stress between the matrix. The flexural strength for all percentages of FRC's is found to be maximum over the strength of normal concrete. The 28-day flexural strength for normal concrete was recorded as 5.07 MPa. The flexural strength for the 0.5% CFRC is found to be maximum, i.e. 60.36 per cent more over the strength of normal concrete.

In the post-cracking stage, the fibers were fully utilized, then it increases the ductility and toughness of all types of FRC. The concrete took full advantage of fibers in flexure. So, in every fiber content, the flexural strength increases over the flexural strength of normal concrete. The maximum increase in flexural strength is due to the coconut fibers provide a bridging effect in concrete.

Table 3.3 Variation of 28 Day Flexural Strength

Mix	Flexural Strength (MPa)	Percentage Difference (%)
CC	5.07	-
CF 0.5	8.13	60.36
CF 1	7.2	42.01
CF 1.5	6.27	23.67
JF 0.5	6.4	26.23
JF 1	5.33	5.13
JF 1.5	5.73	13.02

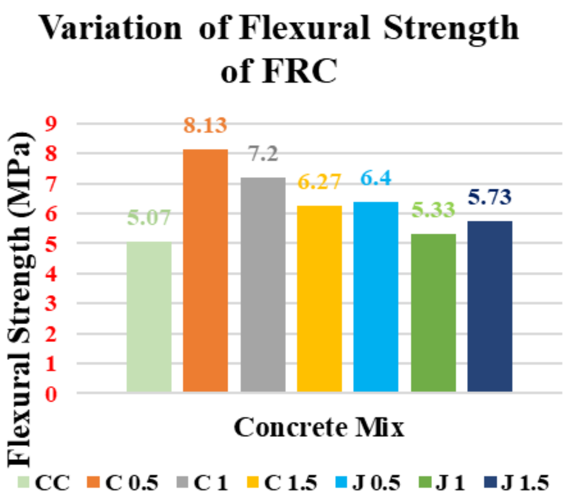

Figure-3.3 Variation of Flexural Strength of Natural FRC

3.4 Split Tensile Strength (28 Day)

The shorter fiber with less fiber content achieves proper distribution in the matrix. It resists cracking due to tensile load in the cylinder. The more abundant fiber with more fiber content gives void in the concrete. As a result, multiple cracking is present in the cylinder. Sometimes bleeding in concrete gives less strength in natural FRC, bleeding water includes mixing water and water absorbed by the fibers. The average split tensile strength of CFRC and JFRC increases by 15.74% and 8.6% compared to normal concrete. The coconut fibers provide a bridging effect & do not permit the cylinder to split.

Table 3.4 Variation of 28 Day Split Tensile Strength

Mix	Split Tensile Strength (MPa)	Percentage Difference (%)
CC	2.52	-
CF 0.5	3.09	22.62
CF 1	2.88	14.29
CF 1.5	2.78	10.32
JF 0.5	3.21	27.38
JF 1	2.64	4.76
JF 1.5	2.36	- 6.35

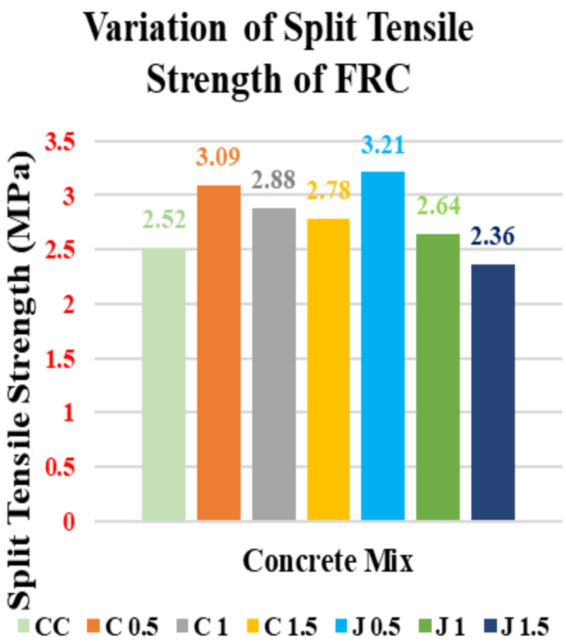

Figure-3.4 Variation of Split Tensile Strength of Natural FRC

IV. CONCLUSION

In this research, different fiber such as coconut, jute is investigated. The fibers are added with the percentage by cement mass. The experiments have been performed to investigate the fresh, mechanical properties of fiber reinforced concrete. The fresh properties are workability in terms of slump cone test. The mechanical properties are compressive strength, flexural strength, and split tensile strength. These properties are also compared with those of ordinary concrete.

The fresh properties investigation reveals:

1. In general, the addition of fibers gives lower workability of FRC. In the case of CFRC and JFRC, the workability reduces considerably i.e., up to 55.81% and 46.51% for 1.5 % CFRC and JFRC respectively.

2. It is due to water absorption and surface area i.e., the shape and size of fiber. It was possible to maintain the workability of CFRC and JFRC by using water, reducing admixtures without increasing the water content.

The mechanical property shows that:

1. The 0.5% coconut, jute fibers may be used to increase the compressive, flexural and tensile strength of FRC.

2. The compressive strength, flexural strength, and split tensile strength of 0.5% CFRC improved by 9.95%, 60.36%, and 22.62% respectively than that of normal concrete. Coconut fibers may use to increase the ductility and toughness of concrete.

3. The compressive strength, flexural strength, and split tensile strength of 0.5% JFRC improved by 11.27%, 26.23%, and 27.38% respectively than that of normal concrete. The addition of jute fiber can reduce the voids in concrete & it creates proper distribution fiber in the matrix.

4. The properties of FRC increases or decreases depending upon the percentage of fiber content.

REFERENCES

1) Mehran Khan and Majid Ali, “Effect of super plasticizer on the properties of medium strength concrete prepared with coconut fiber”, Construction and Building Materials 182 (2018), Pages 703–715.

2) Noor Md. Sadiqul Hasan, Habibur Rahman Sobuz, Md. Shiblee Sayed and Md. Saiful Islam, "The Use of Coconut Fibre in the Production of Structural Lightweight Concrete", Journal of Applied Sciences 12 (9), Pages 831-839, 2012.
3) Mohammad S. Islam and Syed Ju Ahmed, "Influence of jute fiber on concrete properties", Construction and Building Materials 189 (2018), Pages 768–776.
4) Mohammad Zakaria, Mashud Ahmed, Md Mozammel Hoque and Shafiqul Islam, "Scope of using jute fiber for the reinforcement of concrete material", Springer Open, Textiles and Clothing Sustainability (2016).
5) Amit Rai and Dr. Y.P Joshi, "Applications and Properties of Fibre Reinforced Concrete", Journal of Engineering Research and Applications, ISSN:2248-9622, Vol. 4, Issue 5(Version 1), May 2014, Pages 123-131.
6) Report on Fiber Reinforced Concrete Reported by ACI Committee 544.
7) Concrete Technology by M.S. Sheety.
8) IS- 383 –2016 specifications for fine & coarse aggregate from natural sources for concrete.
9) IS 456 – 2000 code of practice for plain and reinforced concrete.
10) IS 516.1959 Method of Tests for Strength of Concrete.
11) IS 10262 2009 Guidelines for concrete mix design proportioning.