PROBABILISTIC STUDY OF COMPRESSIVE STRENGTH OF COIR FIBER REINFORCED CONCRETE

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Abstract – *This study has been carried out to examine the probable range of compressive strength of the coir fiber reinforced concrete at various fiber volume fractions of 0%, 0.2%, 0.4%, 0.6%, 0.8%, 1%, 1.2%, 1.4%, 1.6% and 1.8% examined thoroughly. From this study analysis it is witnessed that the coir fiber reinforced concrete with 1.6% of fiber volume fraction has demonstrated the higher compressive strength in all the circumstances of the above mentioned cases. From the values of skewness and kurtosis obtained by simulation technique indicates that the compressive strength of coir fiber reinforced concrete at various fiber volume fractions is found to follow normal distribution. The probability range of compressive strength of coir fiber reinforced concrete with different volume fraction indicated maximum strength characteristics for 1.6% volume fraction held between 38.2 MPa to 48.8 MPa.*

Key Words: Compressive strength, Coir fiber reinforced concrete.

1. INTRODUCTION

Concrete is the furthermost broadly utilized structure material everywhere throughout the whole world. With advancements in science and innovation in construction industry, the scope of concrete as a structural material, has enlarged. Since concrete is weak in tension and flexure, most commonly, it is strengthened utilizing steel reinforcement bars. However, use of steel support is costly. In the structure of international research, a significant work is going on in the utilization of fast growing, annually sustainable, cheap agricultural crops and crop deposits as likely fiber reinforcement in concrete. Coconut fiber being the most ductile among all natural fibers and it can potential to be utilized as reinforcement substantial in concrete. The fundamental favorable circumstances of natural fibers are that they are low expense and generally accessible asset for a large number of Agricola zones. They would biodegradable, non-abrasive and there will be no distress with wellbeing and safety thought taking care of. Natural reinforced materials are eco-friendly materials by producing less green house gas emissions and pollutants.

2. OBJECTIVES

The objectives of the study are

[1] To govern compressive strength of concrete with incorporation of coir fiber.

[2] To compute the compressive strength of coir fiber reinforced concrete by using probabilistic investigation.

[3] For determination of the probability range of compressive strength of coir fiber reinforced concrete by using Monte-Carlo Technique.

3. MATERIALS AND METHODOLOGY

Materials used in the Mix Design of this study are Cement, Aggregates, Coconut fibers and Water.

3.1 Cement: Cement is a binding substance in the cement concrete. This concrete is utilized for various types of building works where quality and strength are of prime significance. The OPC 53 grade concrete is used in this project.

3.2 Aggregates: In the cement concrete, to give good nature of concrete aggregates is utilized as a part of two size gatherings:

1) **Fine aggregates:** The aggregates containing particle size less than 4.75mm are called as fine aggregates.

The properties of fine aggregates are
i) Specific gravity= 2.55

ii) Fineness modulus= 4.285

2) **Coarse aggregates:** The aggregates containing particle size more than 4.75mm are called as coarse aggregates.

The properties of coarse aggregates are
i) Specific gravity= 2.76

ii) Water absorption= 2%

3.3 Water: Based on the water cement ratio and amount of water content strength and other properties of concrete are dependent. IS 456-2009 code covers the requirement of concrete used in the mix design.

3.4 Coconut fiber: Coconut fiber has been utilized to upgrade concrete and mortar, and has demonstrated to enhance the compressive strength and toughness of concrete and mortar. Length of coconut fiber used in this project was 10mm. Coconut fiber being the most ductile among all natural fibers and it can potential to be used as a reinforcement material in concrete.

3.5 Specimen Casting

[1] Coir fibers having length of 10mm with volume portion of 0.2%, 0.4%, 0.6%, 0.8%, 1%, 1.2%, 1.4%, 1.6% and 1.8% were arbitrarily distributed to get ready CFRC. Concrete is blended physically by hand or by hand mixer.

[2] Concrete and sieved aggregates are first blended altogether, at that point the coconut coir is included according to the rates and lengths determined above, blending is done until an even blend of aggregates and coir is got and after that the required measure of water is added and blended to get an even consistency of concrete mix. Once blended, the solid is utilized before it loses its plasticity condition.

[3] The concrete specimens used for casting are of size 150 x 150 x150mm. All the models are checked and bolts are fixed and all around oiled before use.

[4] The concrete blend is set in 3 layers into the moulds with 25 blows given to each layer for proper compaction using tamping rod.

[5] Care was taken to properly compact the concrete and to prevent honey combing of concrete in the moulds.

[6] The surfaces of the moulds were finished using dry cement to get good surface finish.

[7] The specimen were stored in laboratory atmosphere for 24 hours from the time of adding water to the ingredients, temperature was maintained at 27^0C.

[8] Then they are demoulded for moulds and are marked with white paint according to the percentage of coir.

[9] The moulds are carefully demoulded so the edges are not damaged. They placed in a water tank for curing, care is taken so that they are completely submerged and cured for 28 days before testing.

Compressive Strength of the specimen was determined by using the formula,

$$\text{Compressive Strength} = \frac{P}{b \times d} \text{ MPa}$$

Where,

P= Load in kN

b= Breadth of the specimen in mm

d= Depth of specimen in mm

3.6 Monte Carlo Simulation

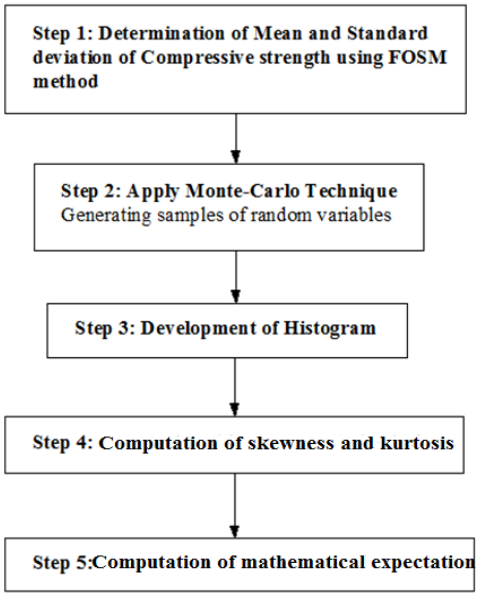

Fig 1: Steps in Monte Carlo Simulation

First order second moment technique is a probability technique to govern the stochastic moments of a task with random input variables. The name is established on the origin which usages a 1st order Taylor series and the 1st and 2nd moments of the input variables.

In this study FOSM technique was utilized to discover mean and S.D of compressive-strength of coir fiber reinforced concrete.

Step 1: In this step the mean and standard deviation of for all values of compressive strength is calculated by using FOSM method.

$$\text{Mean of Compressive strength} = \frac{\text{Mean of Load}}{\text{Mean of Breadth x Mean of Length}}$$

$$\sigma cs^2 = \left(\frac{\partial cs}{\partial l}\right)^2 (\sigma l)^2 + \left(\frac{\partial cs}{\partial b}\right)^2 (\sigma b)^2 + \left(\frac{\partial cs}{\partial d}\right)^2 (\sigma d)^2$$

Where,

CS = Compressive strength of Coir Fiber Reinforced concrete N/mm2

l = Load in KN

b = Breadth of specimen in mm

d = Depth of specimen in mm

Step 2: In this step 1000 random values were generated. By using Monte-Carlo technique the compressive strength values were calculated.

$$y1 = \mu + \sigma\sqrt{2\ln\left(\frac{1}{\gamma 1}\right)} + \cos(2\pi\gamma 2)$$

$$y2 = \mu + \sigma\sqrt{2\ln\left(\frac{1}{\gamma 1}\right)} + \sin(2\pi\gamma 2)$$

Where,

μ = Mean of Compressive strength in N/mm2

σ = Standard deviation of Compressive strength

γ1 and γ2 = Random variables

Step 3: In this step histogram graph will develop for the above 1000 generated compressive strength values.

Step 4: In this step the value of Skewness and Kurtosis were calculated.

Step 5: In this step percentage of probability was determined.

4. RESULTS AND DISCUSSION

In this study results obtained from the conducted experiments on the coir fiber reinforced concrete are presented. Prediction of ranges of properties of Coir Fiber Reinforced Concrete by using Monte-Carlo simulation is illustrated.

Mix Design

For this study mix proportion for 1m3 volume of concrete is as follows below:
Weight of cement = 1.436 kg
Weight of FA = 2.023 kg
Weight of CA = 4.077 kg
Water = 646.58 ml

Table 1: Weight of fibers

Weight of fibers Added to concrete	Percentage of fibers Added to concrete
0	0
0.2	2.872
0.4	5.744
0.6	8.616
0.8	11.488
1.0	14.360
1.2	17.232
1.4	20.104
1.6	22.976
1.8	25.848

The table 1 represents the amount of the fibers that are incorporated in the conventional concrete with respect to the percentage of fibers added.

Table 2: Statistical values of Coir Fiber Reinforced Concrete

SL No	Fiber volume fraction (%)	Length of fiber (mm)	Ultimate load (KN)	Compressive strength (MPa)
1	0	10	8.30	36.88
2	0.2	10	8.90	39.55
3	0.4	10	8.85	39.33
4	0.6	10	9.10	40.44
5	0.8	10	9.30	41.33
6	1.0	10	9.50	42.22
7	1.2	10	9.65	42.88
8	1.4	10	9.70	43.11
9	1.6	10	9.75	43.33
10	1.8	10	9.70	43.11

The table 2 represents the statistical values of coir fiber reinforced concrete. The length of the coir fiber is 10mm. The size of the cube is 150mm x 150mm x 150mm. From the above table it is observed that the compressive strength of coir fiber reinforced concrete increases with increase in fiber volume fraction up to 1.6% after that compressive strength will decrease. The maximum compressive strength is 43.33 MPa with 1.6% fiber volume fraction.

Table 3: Simulated Compressive Strength of Coir Fiber Reinforced Concrete

SL No	Fiber volume fraction (%)	Mean of compressive strength (MPa)	Standard deviation of Compressive strength (MPa)	Range of Compressive strength (MPa)
1	0	36.85	2.076	32.5 to 40 8
2	0.2	39.57	2.226	35 to 43.8
3	0.4	39.29	2.285	35 to 43.98
4	0.6	40.36	1.972	36.8 to 44.6
5	0.8	41.30	2.039	37.5 to 45.6
6	1.0	42.31	2.302	37 to 46.4
7	1.2	42.98	2.263	38.1 to 47.1
8	1.4	43.08	2.58	38 to 48.2
9	1.6	43.29	2.672	38.2 to 48.8
10	1.8	43.09	2.737	38 to 48.8

The compressive strength for 1000 random values was generated using Monte Carlo technique. The average of those 1000 compressive strength values was the mean of compressive strength. Standard deviation was calculated by using FOSM method. The range of compressive strength was found by using normal distribution curve.

The table 3 represents simulated compressive strength values of coir fiber reinforced concrete. From this table it can observe that the experimental compressive strength values matches with the simulated compressive strength values. Monte Carlo technique was used to determine the mean and standard deviation of compressive strength.

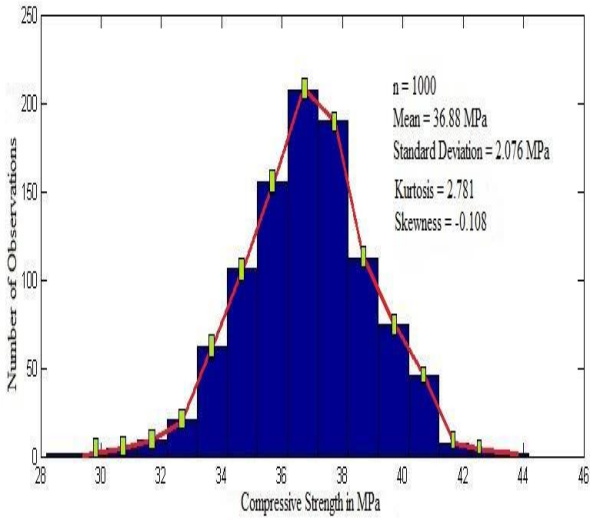

Fig 2: Frequency Distribution of compressive strength of 0% Coir Fiber Reinforced Concrete

The figure 2 represents the frequency distribution of coir fiber reinforced concrete with 0% fiber-volume-fraction. In this figure it can observe that the mean and standard deviation for 1000 random values are 36.88 MPa and 2.076 MPa

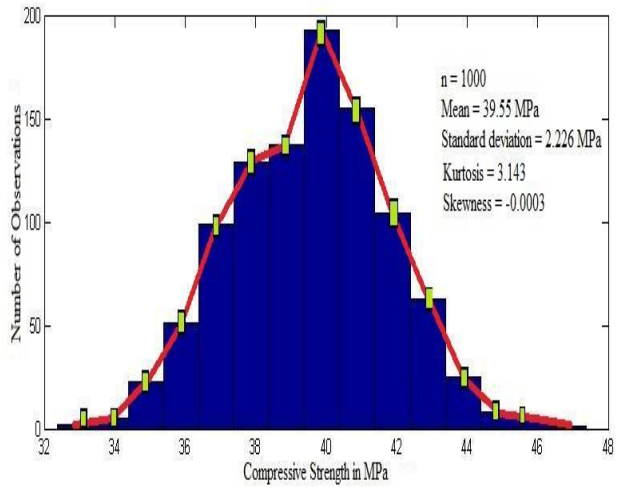

Fig 3: Frequency Distribution of compressive strength of 0.2% Coir Fiber Reinforced Concrete

The figure 3 represents the frequency distribution of coir fiber reinforced concrete with 0.2% fiber-volume-fraction. In this figure it can observe that the mean and standard deviation for 1000 values are 39.55 MPa and 2.226 MPa.

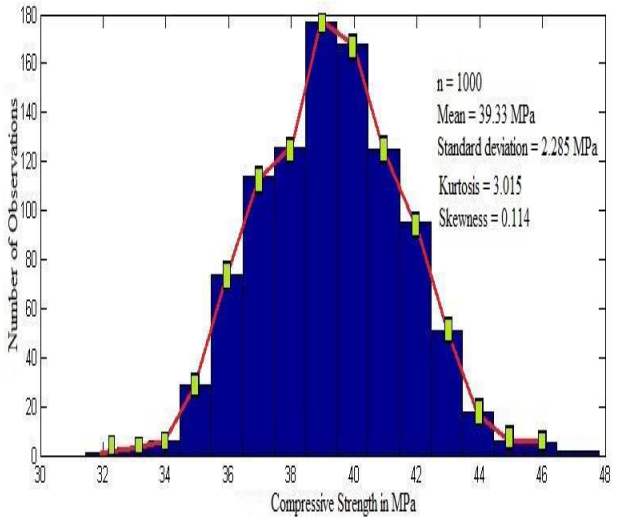

Fig 4: Frequency distribution of compressive strength of 0.4% Coir Fiber Reinforced Concrete

The figure 4 represents the frequency distribution of coir fiber reinforced concrete with 0.4% fiber-volume-fraction. In this figure it can observe that the mean and standard deviation for 1000 values are 39.33 MPa and 2.285 MPa

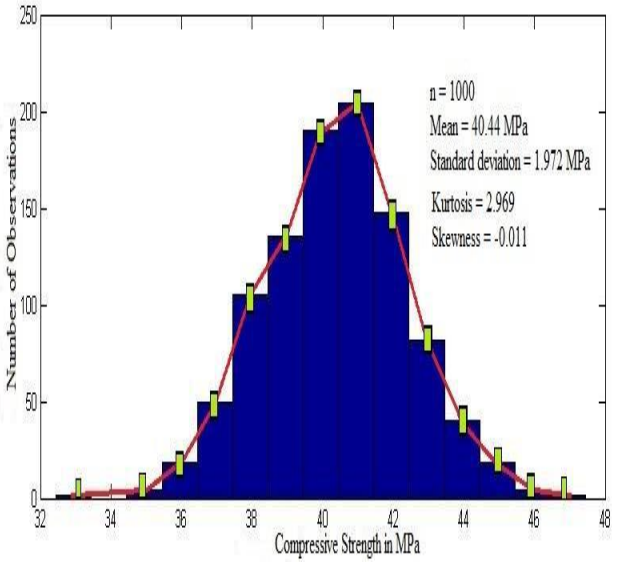

Fig 5: Frequency Distribution of compressive strength of 0.6% Coir Fiber Reinforced Concrete

The figure 5 represents the frequency distribution of coir fiber reinforced concrete with 0.6% fiber-volume-fraction. In this figure it can observe that the mean and standard deviation for 1000 values are 40.44 MPa and 1.972 MPa

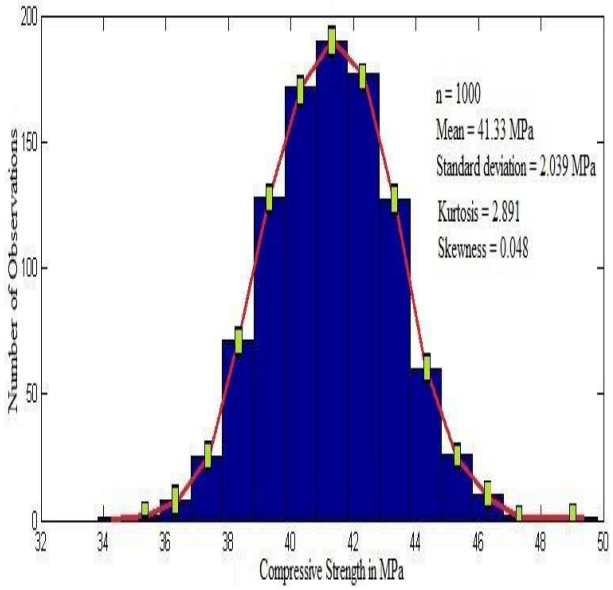

Fig 6: Frequency Distribution of compressive strength of 0.8% Coir Fiber Reinforced Concrete

The figure 5 represents the frequency distribution of coir fiber reinforced concrete with 0.8% fiber-volume-fraction. In this figure it can observe that the mean and standard deviation for 1000 values are 41.33 MPa and 2.039 MPa.

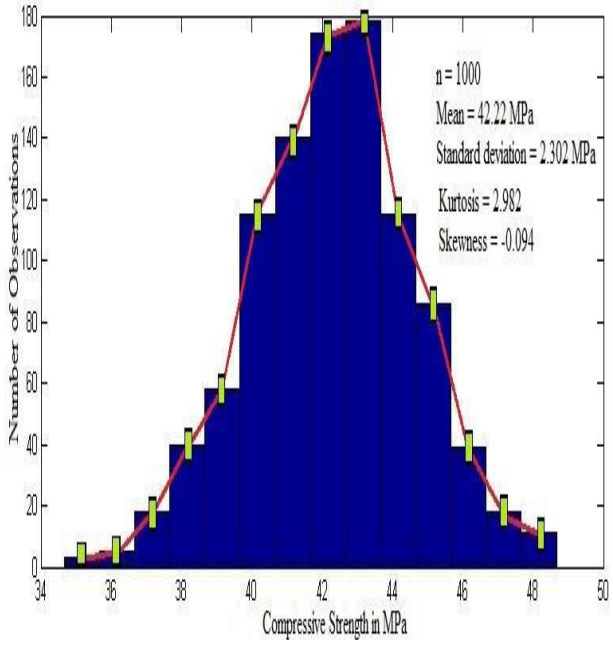

Fig 7: Frequency Distribution of compressive strength of 1% Coir Fiber Reinforced Concrete.

The figure 6 represents the frequency distribution of coir fiber reinforced concrete with 1% fiber volume fraction. In this figure it can observe that the mean and standard deviation for 1000 values are 42.22 MPa and 2.302 MPa.

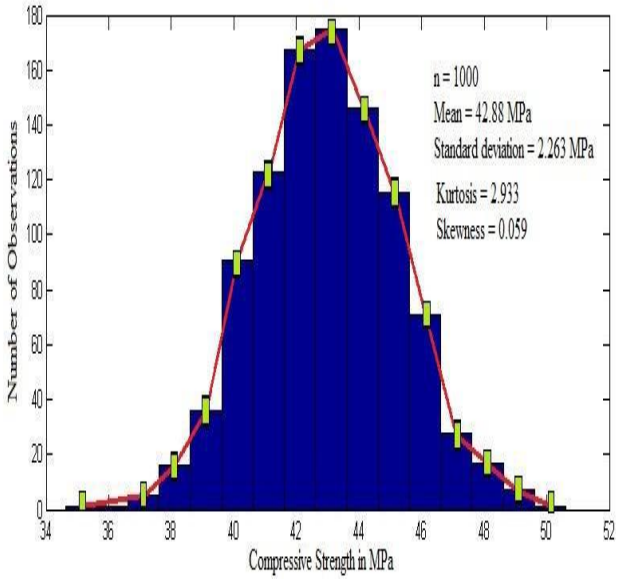

Fig 8: Frequency Distribution of compressive strength of 1.2% Coir Fiber Reinforced Concrete

The figure 7 represents the frequency distribution of coir fiber reinforced concrete with 1.2% fiber-volume-fraction. In this figure it can observe that the mean and standard deviation for 1000 values are 42.88 MPa and 2.263 MPa

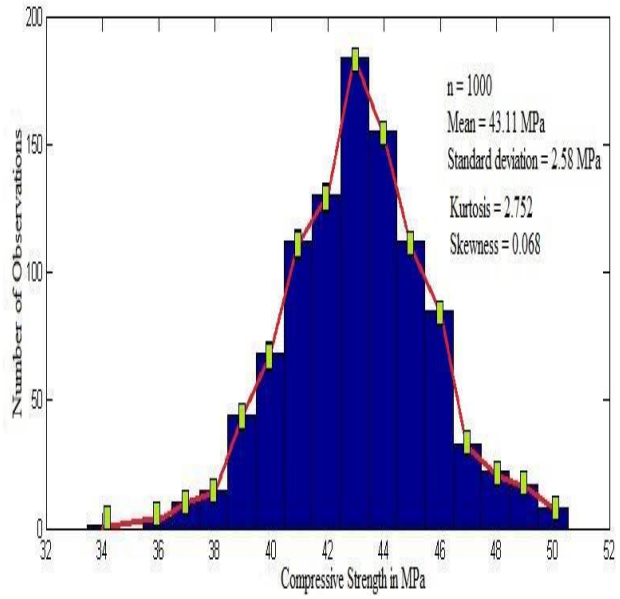

Fig 9: Frequency Distribution of compressive strength of 1.4% Coir Fiber Reinforced Concrete.

The figure 8 represents the frequency distribution of coir fiber reinforced concrete with 1.4% fiber volume fraction. In this figure it can observe that the mean and standard deviation for 1000 values are 43.11 MPa and 2.58 MPa.

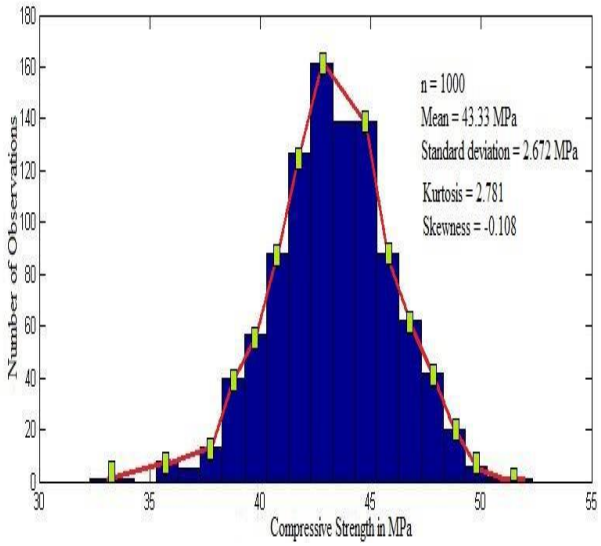

Fig 10: Frequency Distribution of compressive strength of 1.6% Coir Fiber Reinforced Concrete

The figure 9 represents the frequency distribution of coir fiber reinforced concrete with 1.6% fiber-volume-fraction. In this figure it can observe that the mean and standard deviation for 1000 values are 43.33 MPa and 2.672 MPa.

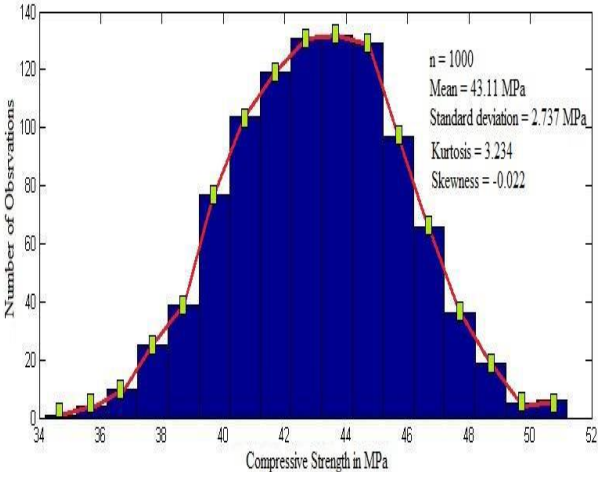

Fig 11: Frequency Distribution of compressive strength of 1.8% Coir Fiber Reinforced Concrete

The figure 10 represents the frequency distribution of coir fiber reinforced concrete with 1.8% fiber-volume-fraction. In this figure it can observe that the mean and standard deviation for 1000 values are 43.11 MPa and 2.737 MPa.

5. CONCLUSIONS

[1] In the current examination from the statistical analysis it is witnessed that the coir fiber reinforced concrete with 1.6% of fiber volume fraction have demonstrated the higher compressive strength in all the circumstances of fiber volume fraction of 0%, 0.2%, 0.4%, 0.6%, 0.8%, 1%, 1.2%, 1.4%, 1.6% and 1.8%.

[2] Monte Carlo method is implemented in the present examination of probabilistic analysis of compressive strength of coir fiber reinforced concrete with different percentage of fiber volume fractions.

[3] The probability range of compressive strength of the coir fiber reinforced concrete with different fiber volume fraction indicated maximum strength characteristics for 1.6% volume fraction held between 38.2 MPa to 48.8 MPa.

[4] This study involves the coir fiber volume fractions incorporated in the conventional concrete and their respective probable ranges of compressive strength.

[5] This study also helps in the adoption of percentage of required fiber volume fractions for desired values of compressive strength.

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