

# Prediction of Compressive Strength of Recycled Aggregate Concrete Using Artificial Neural Network

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**ABSTRACT:** Predicting the compressive strength of concrete has always been a difficulty since the concrete is sensitive to its mixture components, methods of mixing, compaction, curing condition, etc. Scientists have proposed different methods for predicting the compressive strength of concrete. Some of these methods have been successful, however, some others were not suitable enough to predict the compressive strength of concrete. The aim of this study is to evaluate the capability of Artificial Neural Network Model [ANN] in predicting the 28 days compressive strength of concrete. Therefore, considering specific concrete characteristics as input variables, Artificial Neural Network Model is constructed and the compressive strength of concrete is predicted. Results show that ANN is a suitable model to predict the 28 days compressive strength of concrete.

**KEYWORDS:** Recycled concrete aggregates, Artificial Neural Network[ANN], 28 days Compressive strength.

## I. INTRODUCTION

Due to rapid urban development along with trade and industry activities, construction debris creates a problem for environment now a day. In construction waste concrete is the major source which makes disposal problem with more transportation cost. As per Central Pollution Control Board it has been assessed that the solid waste generation is about 48 million tonnes per annum of which 25% are from the construction industry. Simultaneously due to rapid construction early exhaustion of natural aggregates (fine and coarse) occurs and put the impact on the environment. A possible solution to these problems is reuse of construction waste in concrete. Recycled aggregates which can be used in concrete as aggregates is a material derived from the waste concrete is generally produced by two stage of crushing of demolished concrete, screening and removal of contaminants such as reinforcement, wood, plastic etc.,

Recycled aggregate concrete is done using different recycled aggregates replacement ratios, w/c ratios and recycled aggregates with different strengths are used.

Over the last two decades, many investigators have made use of various methods to predict the properties of concrete prepared by different mix proportion. Among these methods, methods based on Artificial Neural Networks (ANN) are quite popular.

ANN is a soft computing technique involving an input layer, one or more hidden layer and an output layer.

Advantages of ANN

- 1) By using ANN it is easy to determine compressive strength of concrete.
- 2) High accuracy in prediction compared to other methods like model tree, non linear regression etc.

## II. OBJECTIVES

The objectives of this study are as follows:

- To utilize the waste generated from the construction units.
- To reduce the time and cost taken to determine compressive strength of concrete in laboratory.
- To determine the physical and mechanical properties of recycled aggregates compared to natural aggregates.



**III. METERIALS USED**

**Cement**

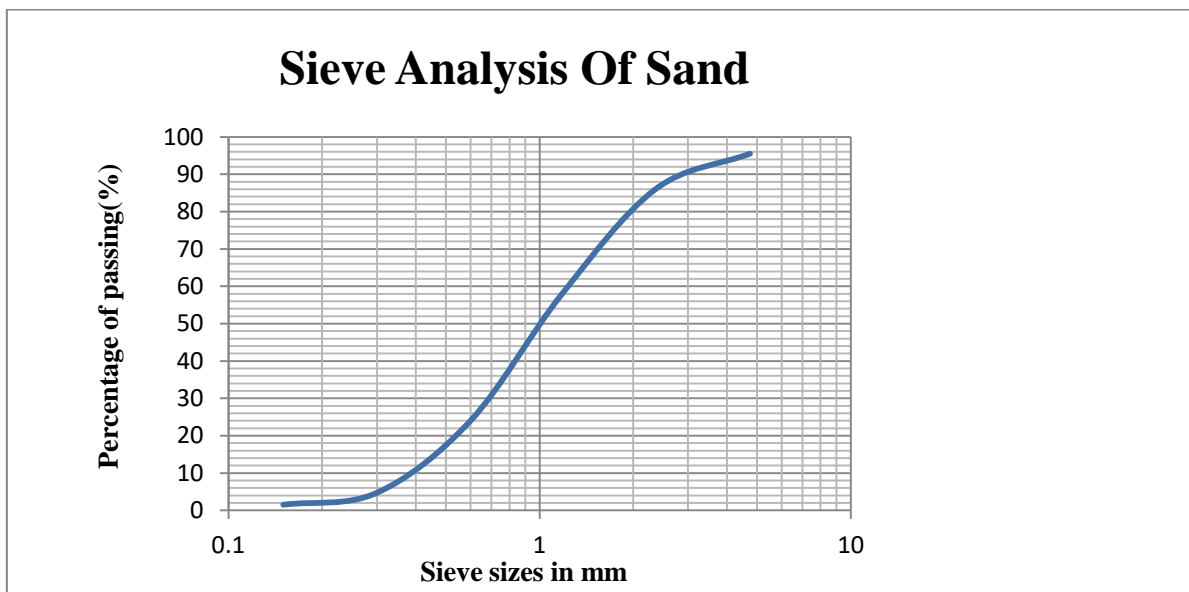
SL NO	CHARACTERISTICS	RESULTS	SPECIFICATIONS
1	Specific gravity	3.14	IS:2720[part 3]
2	Standard consistency	33%	IS:4031[26-33%]
3	Fineness	4%	Not more than 10%
4	Initial setting time	32min	IS:4031[>30min]

**Table 1:** Properties of Cement

**Fine Aggregate**

SL NO	PROPERTIES	TEST RESULT
1	Specific gravity	2.63
2	Optimum moisture content	6%
3	Fineness modulus	3.46
4	Bulk density	1950 kg/m <sup>3</sup>

**Table 2:** Properties of Fine Aggregate



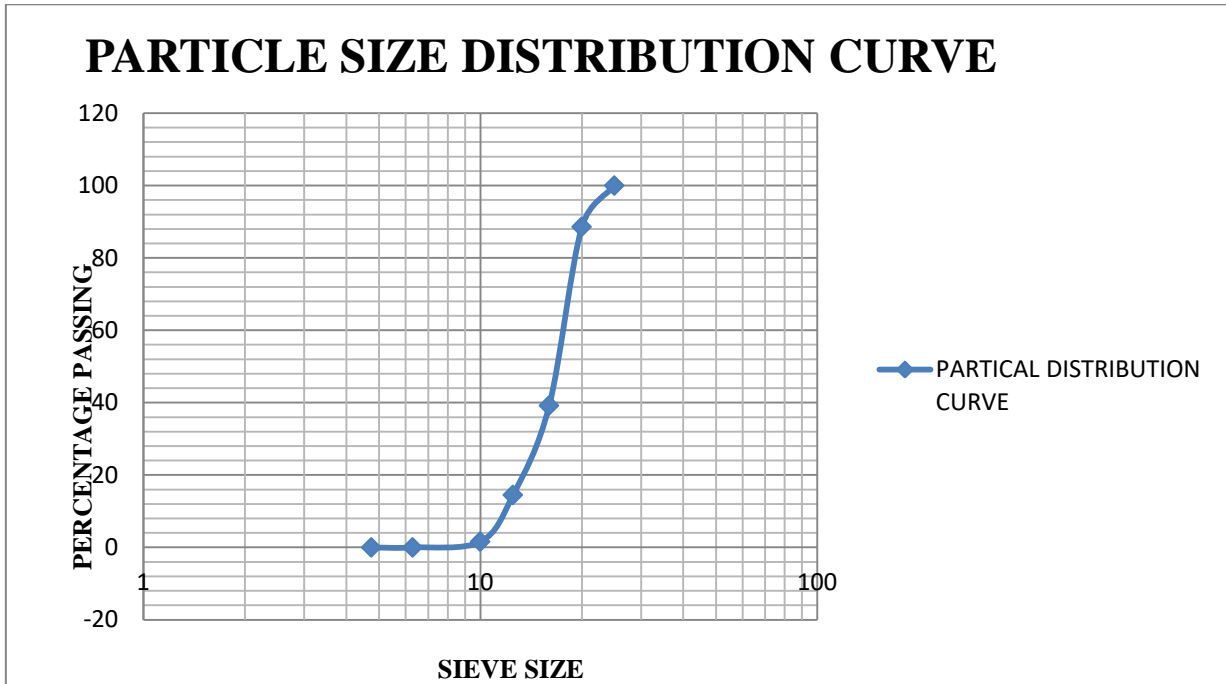
**Graph 1:** Particle Size Distribution Curve of fine aggregate

**Coarse Aggregate**

20mm downsize crushed stone aggregates were procured from a local quarry.

SL NO	PROPERTIES	TEST RESULT
1	Specific gravity	2.64
2	Fineness modulus	5.34
3	Bulk density	1730kg/m <sup>3</sup>
4	Crushing value	20.06%
5	Impact value	17.01%
6	Water absorption	0.6%

**Table 3:** Properties of Coarse Aggregate



**Graph 2:** Particle Size Distribution Curve of Coarse Aggregate

**Recycled Aggregate**

20mm downsize crushed stone recycled aggregates.

SL NO	PROPERTIES	TEST RESULT
1	Specific gravity	2.84
2	Fineness modulus	7.476
3	Bulk density	2280kg/m <sup>3</sup>
4	Crushing value	35.53%
5	Impact value	33.33%
6	Water absorption	0.77%

**Table 4 :** Properties of Recycled Aggregate



**Graph 3:** Particle Size Distribution Curve of Coarse Aggregate

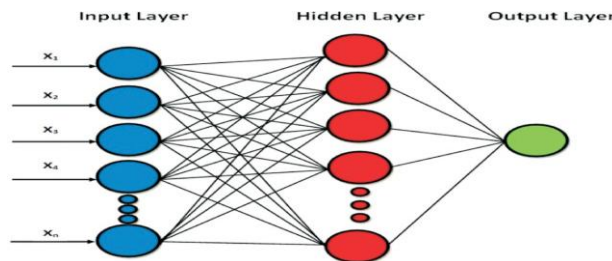
IV. METHODS

**ARTIFICIAL NEURAL NETWORK :** ANN is a mathematical or computational model that tries to simulate the structure or functional aspects of biological neural networks . Though sometimes seems quite simple and small in size, ANN can exhibit amazing capability in modeling the human brain. An ANN model (shown in Fig) consists of a number of interconnected group of artificial neurons, each of which is fully connected to the other through connection weights and receives an input signal from neurons linked to it. These weights, present the effect of an input parameter in the previous layer on the process element, can be adjusted to produce an output needed. Information is transmitted to the output layer from the input layer in one direction, along with which learning process is conducted to minimize the deviation between the actual values and output values. In most cases an ANN is an adaptive system that can change its model according to relevant information that flows through the network during the learning phase. ANN can be used to model nearly any complex relationships between inputs and outputs in data.

$$Y_1 = \mu + s[2 \ln(1/X_1)]0.5 \cos(2\pi X^2) \quad Y_2 = \mu + s[2 \ln(1/X_2)]0.5 \cos(2\pi X^2)$$

Where  $\mu$  = compressive strength from experiment.

s=Standard deviation.



V. RESULT AND DISCUSSION

**Compressive strength test result:** The results from compression test for all specimens which are casted by using recycled aggregates.The compressive strength of specimens with replacement of NA by RCA are listed in Table 5

Specimen code	% Replacement of RCA	Compressive strength in kN/m <sup>2</sup>
RA-0	0	27.55
RA-10	10	26.89
RA-20	20	25.33
RA-25	25	26.55
RA-30	30	26.33
RA-35	35	25.55
RA-40	40	21.11
RA-50	50	18.667
RA-100	100	18.22

TABLE 5 Compressive strength of RCA Concrete.

The experimental results from the compressive tests says that maximum strength that is 27.55 kN/m<sup>2</sup> is achieved in concrete specimen made with NA that is 0% addition RCA. Very less strength that is 18.22 kN/m<sup>2</sup> in the specimen made totally by using RCA. Here this study says there is decrease in strength with the increase in addition of RCA. But, here we can observe that certain percentage of volume replacement can be made to achieve tolerable strength. In this experimental result up to 35% of RCA can be effectively replaced with NA and the respective compressive strength doesn't differ much.

The Input and Output parameters and quantity used model.

%of replacement	Compressive strength	Load taken	S.D of load	Sigma
0	27.55	619875	30993.75	1.892
10	26.89	605025	30251.25	1.835
20	25.33	569925	28496.25	1.701
25	26.55	597375	29868.75	1.802
30	31.11	699975	34998.75	2.211
35	25.55	574875	28743.75	1.720
40	21.11	474975	23748.75	1.358
50	18.667	420007.5	21000.375	1.170
100	18.22	409950	20497.5	1.136

Table 6: Input and Output parameters and quantity used model

Above table 6 is the comparison of compressive strength obtained by experimental results and probabilistic results of RAC of different replacement ratios of RCA. Hence the study proves that the probabilistic results obtained by the computer program can be efficient.

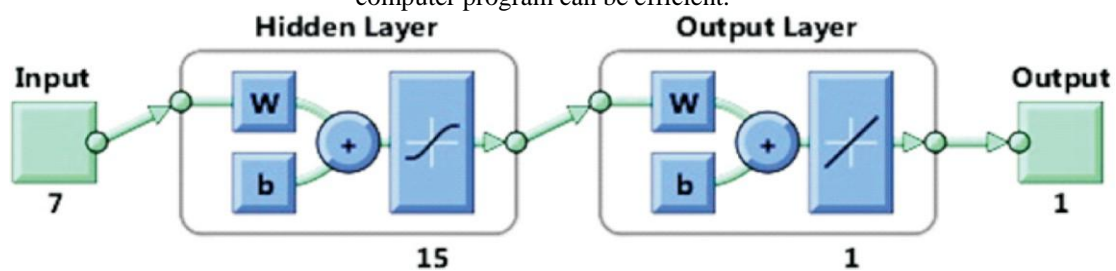
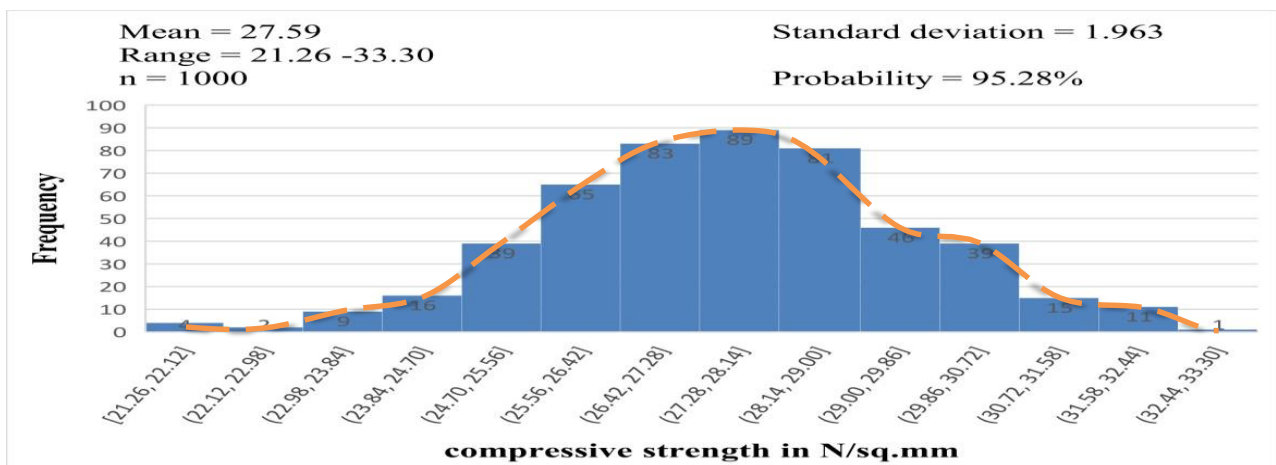


Figure 2. Structure of the ANN model used

**Probabilistic Compressive Strength test results:**

The probabilistic results obtained by using Monte Carlo simulation method are as follows

**Probabilistic Compressive Strength of 0% Recycled Aggregate Embedded Concrete**



Histogram 4.1 showing Probabilistic Compressive Strength of 0% RAC

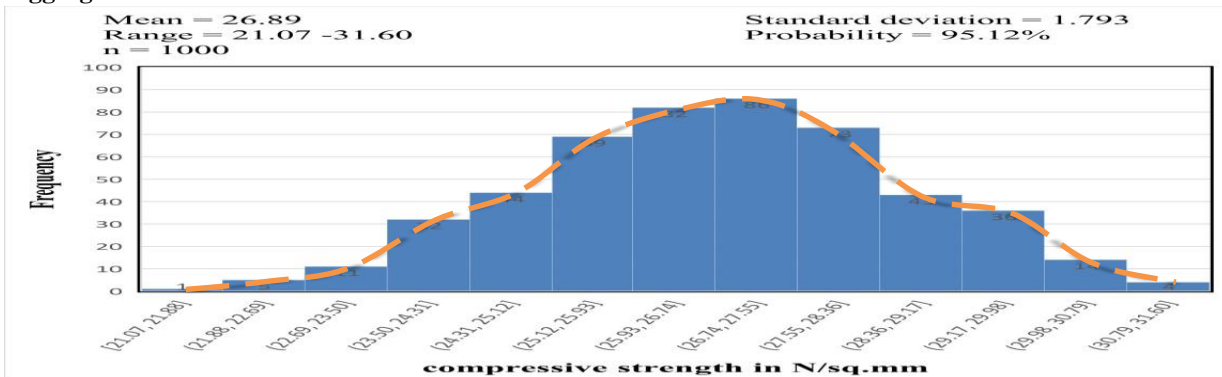


TABLE 7: Probabilistic Compressive Strength results of 0% RAC

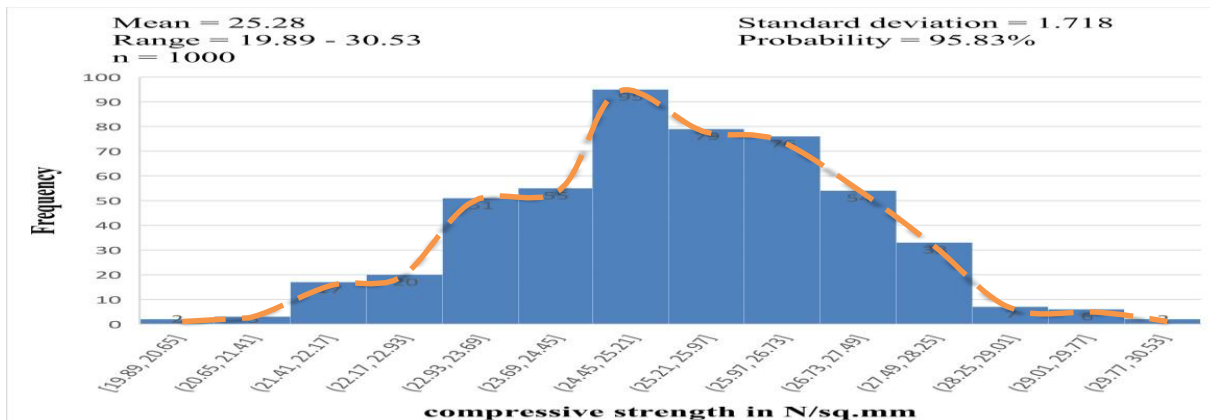
Compressive Strength Range in kN/m <sup>2</sup>	Frequency
21.26 - 22.12	4
22.12 - 22.98	2
22.98 - 23.84	9
23.84 - 24.70	16
24.70 - 25.56	39
25.56 - 26.42	65
26.42 - 27.28	83
27.28 - 28.14	89
28.14 - 29.00	81
29.00 - 29.86	46
29.86 - 30.72	39
30.72 - 31.58	15
31.58 - 32.44	11
32.44 - 33.30	1

\*Above table similar as in different percentage and values in below charts.

Probabilistic Compressive Strength of 10%, 20%, 25%, 30%, 35%, 40%,50% and 100% Recycled Aggregate Embedded Concrete

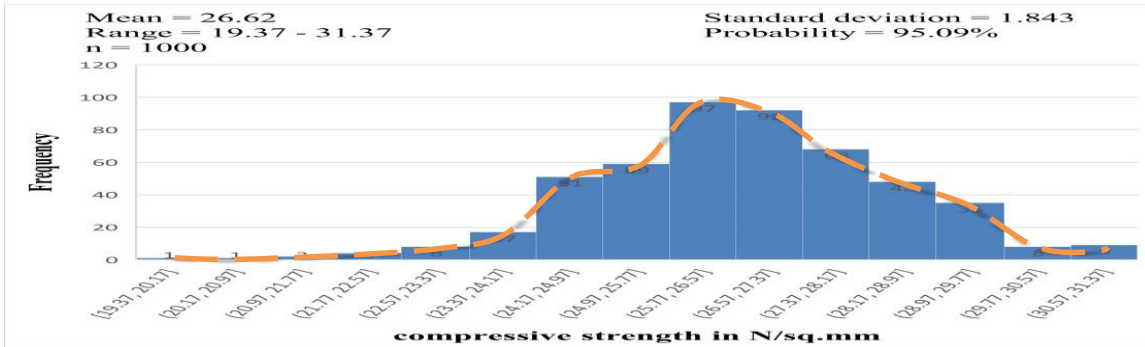


Histogram 4.2 showing Probabilistic Compressive Strength of 10% RAC

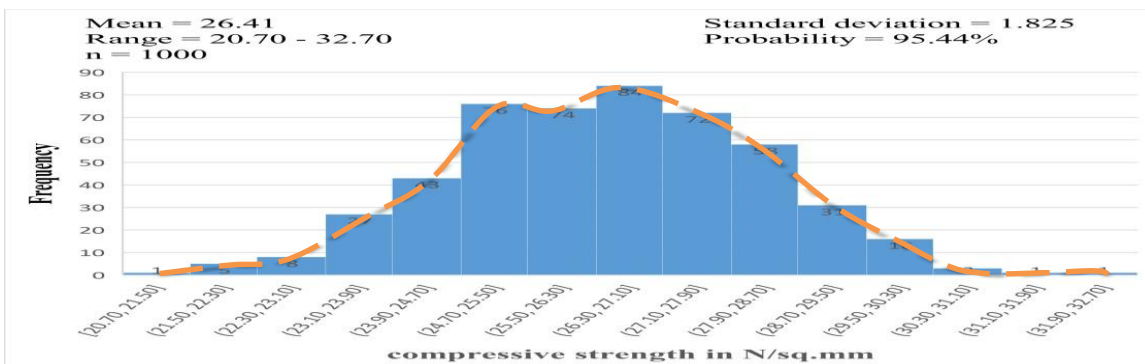


Histogram 4.3 showing Probabilistic Compressive Strength of 20% RAC

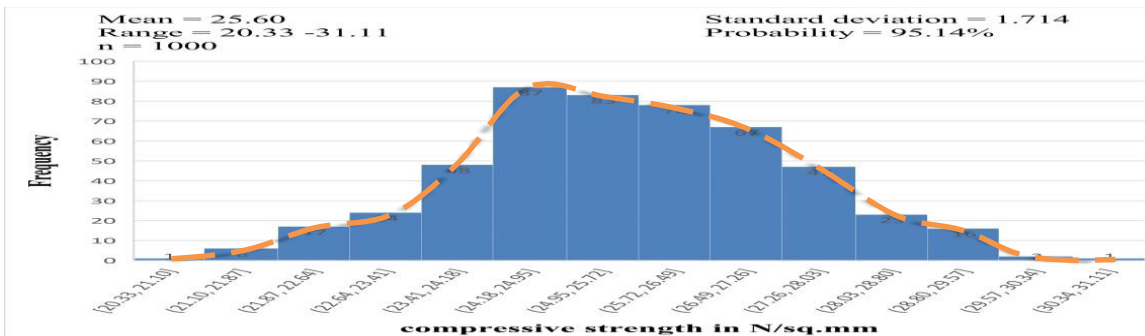




Histogram 4.4 showing Probabilistic Compressive Strength of 25% RAC



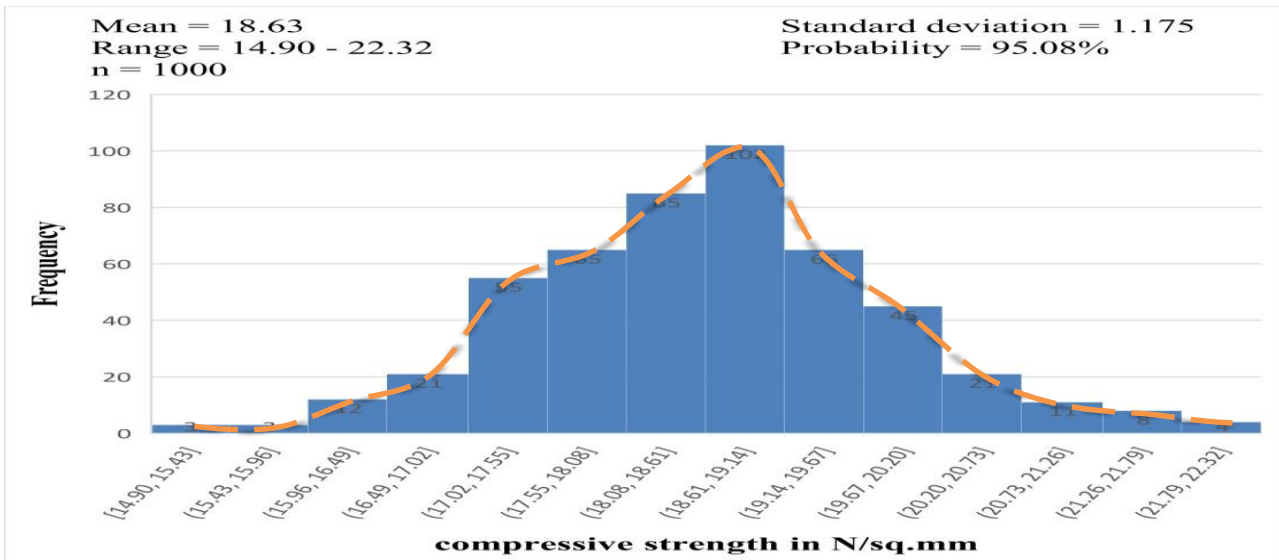
Histogram 4.5 showing Probabilistic Compressive Strength of 30% RAC



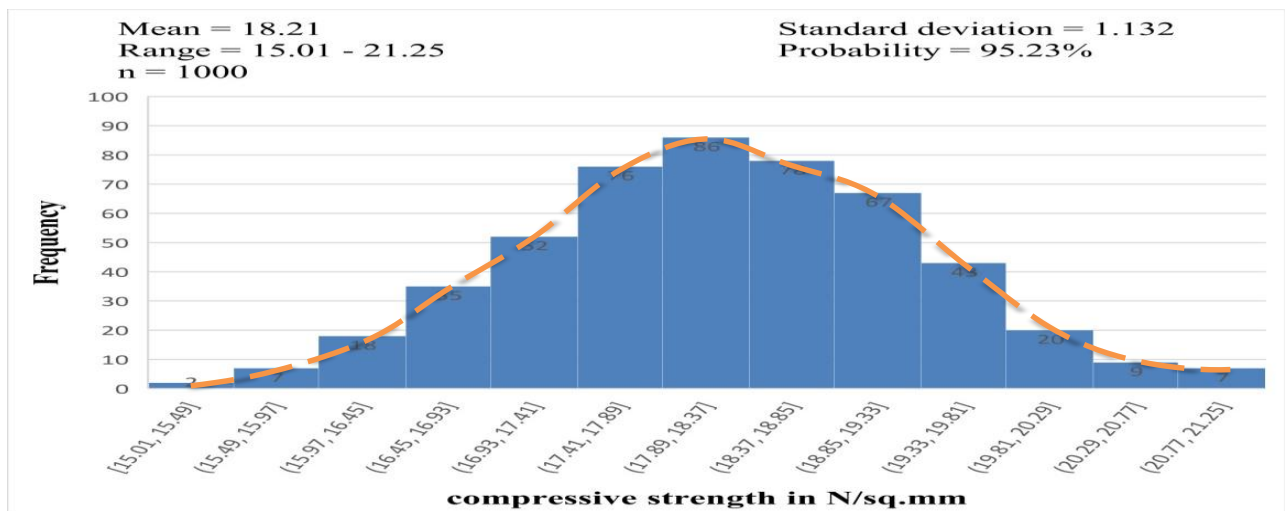
Histogram 4.6 showing Probabilistic Compressive Strength of 35% RAC



Histogram 4.7 showing Probabilistic Compressive Strength of 40% RAC



Histogram 4.8 showing Probabilistic Compressive Strength of 50% RAC



Histogram 4.9 showing Probabilistic Compressive Strength of 100% RAC

### V.CONCLUSION

The study on compressive strength of recycled aggregate embedded concrete by using probabilistic approach. In the study experimental results of compressive strength of concrete specimens formed by using recycled aggregates of replacement ratio (0%, 10%, 20%, 25%, 30%, 35%, 40%, 50% and 100%) with the volume of Natural aggregates. The conclusions of the studies are:

- The compressive strength of recycled aggregate embedded concrete increases up to 35% of replacement of recycled aggregate then it goes on decreases hence it can effectively replace the natural aggregates by recycled aggregates.
- The outcomes obtained from probabilistic investigation are well matched with the experimental outcome. Hence it can effectively have adopted for the determination of compressive strength of concrete with substitution of recycled coarse aggregate.
- The results obtained from monte carlo technique and its procedures are accurate and easier. This technique can be performed by non-engineering users as well.





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