International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.03, February 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

CONCRETE MIX DESIGN USING ARTIFICIAL NEURAL NETWORK

Asst. Prof. S. V. Shah[1], Ms. Deepika A. Pawar[2], Ms. Aishwarya S. Patil[3], Mr. Prathamesh S. Bhosale[4], Mr. Abhishek S. Subhedar[5], Mr. Gaurav D. Bhosale[6]

[1]*Assistant Professor, Department of Civil Engineering,*
Nanasaheb Mahadik College of Engineering, Peth.
[2,3,4,5,6]*Nanasaheb Mahadik College Of Engineering, Peth.*

ABSTRACT

The no of trial mixes and tests need to be performed to check different design parameters for satisfactory of mix proportion design. Therefore it consume lot of time to overcome this artificial neural network is used for approximate proportioning of concrete mixes. The ANN model is based on 5 input parameters such as cement, sand, coarse aggregate, and water and fineness modulus. ANN is used to reduce number of trials need to be perform in laboratory as well as in field. ANN is very helpful in saving lot of time cost of materials as well as labor. ANN gives higher accuracy.

Keywords: - Artificial neural network (ANN), concrete mix, Compressive strength of 7, 14 and 28 days.

I. INTRODUCTION

Concrete because of its flow ability in most complicated form means it is able to take any desired shape we want when it is wet and strength development characteristic when it hardens so because of its ability while wet of taking shape and strength developing characteristic when harden it is most widely used construction material. Concrete is used to protect structure which is subjected to severe stress conditions. Concrete is the most widely used construction material. It is a composite material which is obtained by mixing cement, water and aggregate. The production of concrete involves number of operations according to prevailing site conditions. To produce concrete of acceptable quality the various ingredients of varying characteristics can be used. The strength, durability and other characteristics of concrete depend upon the properties of its ingredients, the proportions of the mix, the method of compaction and other controls. The popularity of concrete as a construction material is due to the fact that is made from commonly available ingredient. Among a various properties of concrete its compressive strength is considered to be the most important. However workability of concrete plays an important role in the mix design. Other factors such as water cement ratio, fineness modulus of aggregate and specific gravity of cement have their own importance in mix design.(8)

The development of normal concrete i.e. mix design is carried out using certain empirical relationships among design parameters, developed from the past experience .a normal concrete mix of required strength can be achieved after carrying out several trial on mix proportions. Artificial neural network (ANN) is a network consisting of several nodes, known as neuron. The connection between this neuron carries weight, which define the relationship between input and output data. ANN is a technique that can be used for the problems, where no solution algorithm is known. The mix design of concrete can be put under same category of problems. Again, development of concrete which requires large sets of trial is very complex problem in itself. The feature of ANN to establish relationship between input and output data can be used to establish some kind of various design parameters of normal as well as high performance concrete. Use of artificial neural network for the development of concrete mix may reduce the requirement of large no of trials. To develop artificial neural network model for concrete mix design, sufficient set of mix proportions with corresponding characteristic strength, water content and fineness modulus of aggregate are required for training of neural network. since sufficient data for mix design is not available, mix design data corresponding above mention characteristics has been generated experimentally for the training of ANN. Further using this data ANN modeling is done for concrete mix design. (2)

II. LITERETURE REVIEW

1. "Prediction of Concrete Mix Proportion using ANN Technique" (2015) Sourav Das.

In this paper concrete mix design is carried out based on some empirical relationships and the experience of the engineer. To train the ANN model a database of large number of mix proportions of M25 grade of concrete is prepared using PPC cement. To get the output as mix proportion of various ingredients, input parameters are Target Mean Strength, Workability in terms of slump, W/C Ratio, Specific Gravity of Cement, Sand & Coarse Aggregate and Grading Zone of Fine Aggregate. The trained network is validated with a set of five mix proportions which were not used in the training process. The average percentage error is observed as 0.193%. On comparison with linear regression analysis the ANN model is found to be more efficient. (7)

2. "Concrete Mix Design Using Neural Network" (2014) Rama Shanker.

Basic ingredients of concrete are cement, fine aggregate, coarse aggregate and water. In this paper to produce a concrete of certain specific properties, optimum proportion of these ingredients are mixed. The important factors which govern the mix design are grade of concrete, type of cement and size, shape and grading of aggregates. Concrete mix design method is based on experimentally evolved empirical relationship between the factors in the choice of mix design. Basic draw backs of this method are that it does not produce desired strength, calculations are cumbersome and a number of tables are to be referred for arriving at trial mix proportion moreover, the variation in attainment of desired strength is uncertain below the target strength and may even fail. To solve this problem, a lot of cubes of standard grades were prepared and attained 28 days strength

determined for different combination of cement, fine aggregate, coarse aggregate and water. An artificial neural network (ANN) was prepared using these data. The input of ANN were grade of concrete, type of cement, size, shape and grading of aggregates and output were proportions of various ingredients. With the help of these inputs and outputs, ANN was trained using feed forward back proportion model. Finally trained ANN was validated, it was seen that it gave the result with/ error of maximum 4 to 5%. Hence, specific type of concrete can be prepared from given material properties and proportions of these materials can be quickly evaluated using the proposed ANN. (5)

3. "Concrete Mix Design Using Artificial Neural Network" (2014), Sakshi Gupta.

In this paper concrete mix design is a process based on sound technical principles for proportioning of ingredients in right quantities. This paper demonstrates the applicability of Artificial Neural Networks (ANN) Model for approximate proportioning of concrete mixes. For ANN a trained back propagation neural network is integrated in the model to learn Experimental data pertaining to predict 7, 14 and 28-day compressive strength which have been loaded into a model, containing 55 concrete mixtures. The ANN model proposed is based on 5 input parameters such as cement, sand, coarse aggregate, and water and fineness modulus. The proposed concrete mix proportion design is expected to reduce the number of trials in laboratory as well as field, saves cost of material as well as labor and also saves time as it provides higher accuracy. The concrete designed is expected to have higher durability and hence is economical. (6)

4. "Artificial neural network for concrete mix design" (2013) Ahsanul kabir.

In this paper concrete mix design is complicated, time consuming, experience based and uncertain task. Most of the time to achieve the designed strength one has to depend on the past experience in mix design process and some sort of trial and error method. The final acceptance comes after the quality control test result (water, cement, coarse aggregate fine aggregate) to achieve the desired strength. In this paper, artificial neural network is being used to predict the concrete mix ratio to achieve the desired strength. The parameters such as , 28 days strength max gravel size ,presence of air, fineness modulus of sand ,gravels dry rod unit weight, water content ratio are used to predict mix ratio(weight basis) in terms of fine aggregate cement ratio and coarse aggregate cement ratio.(1)

5. "Artificial Intelligence in Civil Engineering." (2012) Yujun Zheng.

Artificial intelligence is a branch of computer science, involved in the research, design, and application of intelligent computer. Traditional methods for modeling and optimizing complex structure systems require huge amounts of computing resources, and artificial-intelligence-based solutions can often provide valuable alternatives for efficiently solving problems in the civil engineering. This paper summarizes recently developed methods and theories in the developing direction for applications of artificial intelligence in civil engineering, including evolutionary computation, neural networks, fuzzy systems, expert system, reasoning, classification, and learning, as walls others like chaos theory, cuckoo search, firefly algorithm, knowledge-based engineering,

and simulated annealing. The main research trends are also pointed out in the end. The paper provides an overview of the advances of artificial intelligence applied in civil engineering. (4)

6. "Design of Concrete Mixes Using Artificial Networks" (2010) Majid Al-gburi.

The artificial neural network modeled to prediction the mix proportion of concrete mixes were built in this study. The input parameters were slump, percentage of fine aggregate from total aggregate content, fineness modulus of fine aggregate, max aggregate size of coarse aggregate and compressive strength, while the output were cement, sand, gravel, and water contents. In this paper the proposed concrete mix proportion design algorithm is expected to reduce the number of trial and error, save cost, laborers and time. The system was trained and tested using 493 mixes chosen from the local data, 443 of them used for training while 50 mixes used for testing, results indicate that the mix proportion can be predicted accurately by using the artificial neural network method compared to experimental local mixes.(2)

7. "Neural Networks and Its Application in Engineering" (2009) Oludele Awodele.

Neural Network (NN) has emerged over the years and has made remarkable contribution to the advancement of various fields of endeavor. The purpose of this work is to examine neural networks and their emerging applications in the field of engineering, focusing more on Controls. In this work, we have examined the various architectures of NN and the learning process. The needs for neural networks, training of neural networks, and important algorithms used in realizing neural networks have also been briefly discussed. Neural network application in control engineering has been extensively discussed, whereas its applications in electrical, civil and agricultural engineering were also examined. We concluded by identifying limitations recent advances and promising future research directions. (3)

III. OBJECTIVES

a) To train and test of ANN model for concrete mix design, using standard compressive Strength of concrete :- For ANN trained back propagation neural network is integrated in the model to learn experimental data to predict 7,14,28 days compressive strength of concrete, which have been loaded in model, containing 207 concrete mixtures.

b) To proportionate the ingredients of concrete to achieve the desired strength at site:-in this present paper concrete mix design is done by IS CODE method.

c) To compare the result of conventional method of concrete mix to the software analysis:-comparison on the basis of results available on both from software as well as site is done.

IV. CONCRETE MIX DESIGN MANUALLY

Mixture proportioning refers to the process of determining the quantities of concrete ingredients, to achieve the specified characteristics of concrete. properly proportioned concrete mix should possess quantities such as

workability, durability, strength and uniform appearance .In order to achieve such characteristics, the engineer must determine the proportion of cement ,water, fine and coarse aggregates. Only with the proper selection of materials of above quality of concrete may be obtained at construction site. The engineer is responsible for assuring concrete is properly proportioned, placed, mixed and cured.

Because of many assumptions and estimations underlying the theoretical calculations, the mix proportions for the actual ingredients to be used do not provide correct answer. Therefore proportions of these mixes checked and adjusted by means of laboratory trial mixes and tests until fully satisfactory ix is obtained.

Many factors influencing concrete mix proportioning, and their mutual relationship is so complicated that it is impossible to formulate mathematical models to express their mutual actions and reactions. Adjustment is always performed by taking into account the information of concrete quality control tests.

However, it is still impossible to avoid the personal ,physical ,mechanical errors and uncertainties that encountered in environment.

The purpose of this paper is to discuss development of artificial neural network model for concrete mix design to minimize the error that is avoidable in concrete ix proportioning and adjustments.

V. CONCRETE MIX DESIGN BY ARTIFICIAL NEURAL NETWORK

5.1 MIX RATIO

In case of problems of mix design, practical knowledge, judgments and trial and error process are main basis. It will be a great help to solve mix design problems if a system is established that can do entire functions mentioned above with greater efficiency. This is a prime reason for choosing artificial neural network to solve the problems with greater efficiency. The input values were cement, sand, coarse aggregate, water and fineness modulus and output strength.

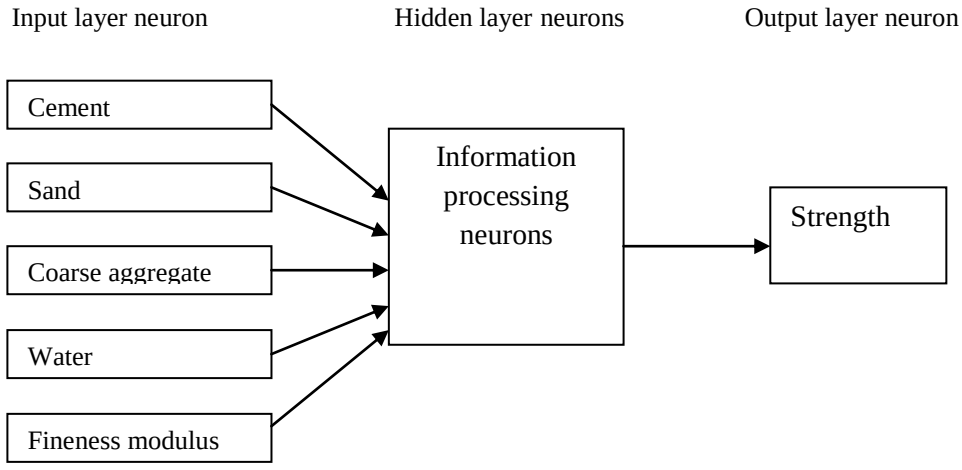

Fig: ANN for Predicting The Mix Ratio

5.2 ANN TRAINING

During training process, data are passed to the input layer and then it passes from layer to layer maintaining the system of forward pass. In this system, each neuron in hidden layer receives input from input layer's neurons which are already being multiplied by the adjacent weight and then summed up, in some cases it is modified by adding bias. Afterwards it passes through the transfer function and delivers it for the output layer for preparing results maintaining same procedures. Comparing the output values with the target values, errors are calculated. Training of network is nothing but adjusting weights between the connections of the neurons.

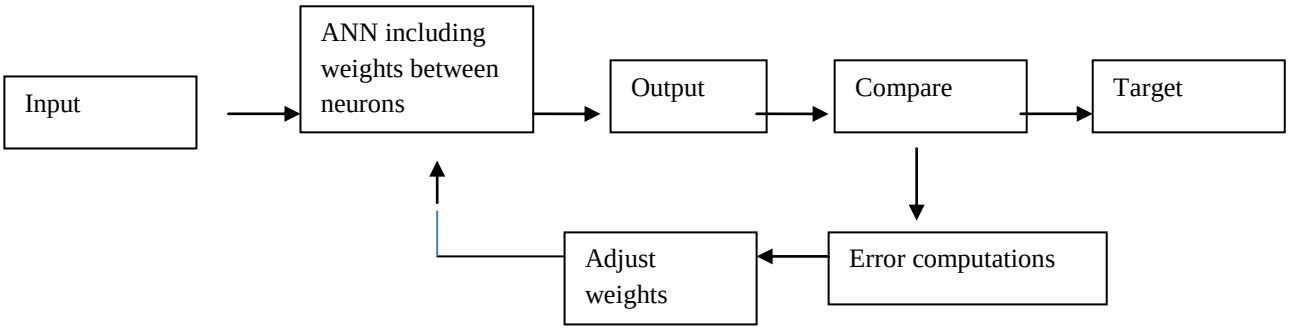

Fig: Training Process of ANN

5.3 ANN TESTING

In total 206 data sets are used for this study. Among them 70% data is used for training and remaining data for testing. Data used for testing the trained ANN are selected randomly.

Three back-propagation algorithms are used to train the network and to check the performance of ANN

Levenberg-Marquardt (LM) Algorithm

Bayesian regulation (BR) Algorithm

Scaled conjugate gradient (SCG) Algorithm

5.4 PERFORMANCE EVALUATION

Data are used to train the ANN with Back-Propagation Algorithms and tested for best performance. The performances of algorithms are evaluated by four expressions root mean square error, Correlation coefficient, Mean absolute error.

5.4.1 ROOT MEAN SQUARE ERROR

Root-Mean-Square Error (RMSE) is a frequently used measure of the differences between actual values and values predicted by a model. RMSE index ranges from 0 to infinity, with 0 corresponding to a perfect fit.

5.4.2 CORRELATION COEFFICIENT (R)

The correlation coefficient measures the statistical correlation between the predicted and actual values. Correlation coefficients are expressed as values between +1 and -1. A coefficient of +1 indicates a perfect positive correlation. A coefficient of zero indicates that there is no distinguishable relationship between the variables.

5.4.3. MEAN ABSOLUTE ERROR (MAE)

Mean absolute error is a quantity which is very commonly used to measure the accuracy of predicted values. The MAE measures the average magnitude of the errors in a set of forecasts, without considering their direction.

VI. COMPARISON BETWEEN MIX PROPORTIONING MANUALLY AND SOFTWARE ANALYSIS

In this work multilayered feed forward neural network with a back propagation algorithm was adopted using the popular MATLAB software [MATLAB R0014B]. To train the ANN models, LEVENBERG-MARQUARDT and BAYESIAN REGULATION algorithm is used. The convergence of the models in training is based on minimizing the error for mean squared error. The LM model is found to be faster and appropriate as compare to Bayesian regulation model. LM model is suitable for small and applicable for most of the problem.

Concrete cubes were casted at site according to both the mix proportions available from software as well as manual design. These cubes are tested on regular interval of 7, 14& 28 days with the help of universal testing machine.

VII. RESULT

Table no 1 gives the mix proportions and table no 2 gives strength of concrete at 28 days.

Table no: 1

Mix proportion	By manually	By software
M20	1: 1.4: 3.03	1: 1.5: 3.04
M30	1: 1.03: 2.35	1: 1.09: 2.25

Table no: 2

	strength	
	For M20	For M30
By manually	23.12	29.52
By software	20.15	30.5

VIII. CONCLUSION

This study demonstrates that the ANN model can be very convenient tool in order to solve mix design problems .ANN can be used efficiently for most of the noisy problems. This study emphasis is given to predict strength of concrete by testing and training of ANN model of mix proportions. The accuracy of prediction depends upon number of training data and its variations. The proposed ANN was validated and outputs predicted by developed neural network were fairly accurate in a range of 90 to 95%.More reliable predictions can be made with more data and wide variations. The application of artificial intelligence in the field of mix design is very appropriate in order to preserve valuable time at reasonable cost.

REFERENCES

A) Journals:

[1] AhsanulKabir, MdMonjurulHasan(2013) "artificial neural network for concrete mix design."

[2] Majid al-gburi, salim t yousif (2010) "design of concrete mixes using artificial neural networks."

[3] OludeleAwodele and OlawaleJegede(2009) "Neural Networks and Its Application in EngineeringDept. of Computer Science and Mathematics,Babcock University Nigeria."

[4] Pengzhen Lu, Shengyong Chen, and YujunZheng (2012) "Artificial Intelligence in Civil Engineering."

[5] Rama Shanker, Anil Kumar Sachan (2014) "Concrete Mix Design Using Neural Network."

[6] Sakshi Gupta National Institute of Technology (2014) "Concrete Mix DesignUsing Artificial Neural Network."

[7] Sourav Das, P. Pal& R. M. Singh (2015) "Prediction of Concrete Mix Proportion using ANN Technique."

B) Books:

[1] Gambhir, M.L., "Concrete Technology", Tata Mcgraw Hill, 1993.
[2] M. H. Hassoun, "Fundamentals of Artificial Neural Networks."
[3] M. S. Shetty, "Concrete Technology."

C) I.S. Codes:

[1] Indian Standards, "Code of practice for plain and reinforced concrete",
[2] IS 456-2000, 3rd edition, Bureau of Indian Standards, New Delhi.
[3] Indian Standards "Specification for coarse and fine aggregate for natural
[4] Source of concrete", IS 383-1970, Indian Standards Institution, New Delhi.
[5] Indian standard "concrete mix proportioning" IS 10262:2009.