Review on Concrete Mix Design Using Artificial Neural Network

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Abstract-*For satisfactory mix proportion design we have to perform number of trial mixes and tests to check different design parameters. Therefore it is very time consuming work. To overcome these difficulties artificial neural network (ANN) can be used which predicts the mix proportions based on experimental mix design data. The learning processes in artificial neural networks use previous experimental mix design data to predict mix proportions specified by various input parameters.*

Keywords-Artificial Neural Network.

I. INTRODUCTION

Concrete is the most widely used construction materials because of its flowability in most complicated form i.e. its ability to take any shape while wet, and its strength development characteristics when it hardens. Generally concrete is used to build protective structures, which are subjected to several extreme stress conditions. Concrete is the most widely used construction material manufactured at the site. This composite material is obtained by mixing cement, water and aggregate. Its production involves a number of operations according to prevailing site conditions. The ingredients of widely varying characteristics can be used to produce concrete of acceptable quality. 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 and can be tailored to functional requirements in a particular situation. 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. (9)

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. (7)

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. (8)

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. (6)

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.(4)

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. (5)

8. "A concrete mix proportion design algorithm based on artificial neural Networks." (Jan 2006) Tao Ji.

The concepts of five parameters of nominal water–cement ratio, equivalent water–cement ratio, average paste thickness, fly ash–binder ratio, grain volume fraction of fine aggregates and Modified Tourfar's Model were introduced. It was verified that the five parameters and the mix proportion of concrete can be transformed each other when Modified Tourna's Model is applied. The behaviors (strength, slump, et al.) of concrete primarily determined by the mix proportion of concrete now depend on the five parameters. The prediction models of strength and slump of concrete were built based on artificial neural networks (ANNs). The calculation models of average paste thickness and equivalent water–cementation can be obtained by the reversal deduction of the two prediction models, respectively. A concrete mix proportion design algorithm based on away from aggregates to paste, a least paste content, Modified Tourna's Model and ANNs was proposed. The proposed concrete mix proportion design algorithm is expected to reduce the number of trial and error, save cost, laborers and time. The concrete designed by the proposed algorithmic expected to have lower cement and water contents, higher durability, better economical and ecological effects.(10)

9. "Artificial neural networks: fundamentals, computing, design, and application.", (2000)I.A. Basheera.

Artificial neural networks (ANNs) are relatively new computational tools that have found extensive utilization in solving many complex real-world problems. The attractiveness of ANNs comes from their remarkable information processing characteristics pertinent mainly to nonlinearity, high parallelism, fault and noise tolerance, and learning and generalization capabilities. This paper aims to familiarize the reader with ANN-based computing (neurocomputing) and to serve as a useful companion practical guide and toolkit for the ANNs modeler along the course of ANN project development. The history of the evolution of neurocomputing and its relation to the field of neurobiology is briefly discussed. ANNs are compared to both expert systems and statistical regression and their advantages and limitations are outlined. A bird's eye review of the various types of ANNs and the related learning rules is presented, with special emphasis on back propagation (BP) ANN theory and design. A generalized methodology for developing successful ANNs projects from conceptualization, to design, to implementation, is described. The most common problems that BPANNs developers face during training are summarized in conjunction with possible causes and remedies. Finally, as a practical application, BPANNs were used to model the microbial growth curves of S. Flexner. The developed model was reasonably accurate in simulating both training and test time-dependent growth curves as affected by temperature and ph.(3)

10. "Artificial neural network." (1996) Anil K. Jain.

Numerous advances have been made in developing intelligently stems, some inspired by biological neural networks. Researchers from many scientific disciplines are designing artificial neural networks (A"s) to solve a variety of problems in pattern recognition, prediction, optimization, associative memory, and control (see the "Challenging problems" sidebar). Conventional approaches have been proposed for solving these problems. Although successful applications can be found in certain well-constrained environments, none is flexible enough to perform well outside its domain. ANNs provide exciting alternatives, and many applications could benefit from using them.' This article is for those readers with little or no knowledge of ANNs to help them understand the other articles in this issue of Computer. We discuss the motivations behind the development of A " s , describe the basic biological neuron and the artificial computational model, outline network architectures and learning processes, and present some of the most commonly used ANN model. (2)

III. OBJECTIVES

a) To train and test of ANN model for concrete mix design, using standard compressive Strength of concrete.
b) To proportionate the ingredients of concrete to achieve the desired strength at site.
c) To compare the result of conventional method of concrete mix to the software analysis.

IV. METHODOLOGY

Phase 1- Study of Literature:

In this phase, first of all we have collected the research papers, books and IS codes related to artificial neuron network (ANN) and concrete mix design. Then we have discussed the necessity and future scope of subject selected. From the reading of various papers, we come to know that, in order to complete the project we need to learn matrix laboratory software.

Phase 2- learning of software:

In the second phase we are going to learn all basic about matlab software and all other essential part which is required to design mix proportions.

Phase 3- Mix proportion design manually:

In this phase we are going to design of mix proportions for concrete manually on the basis our concrete technology knowledge.

Phase 4- Mix proportion design in the matlab software:

In this phase we are going to design matlab software, for the mix proportions available.

Phase 5- Cube casting at site according to software analysis:

In this phase we are going to cast 4 cubes of concrete according to data available from software analysis.

Phase 6- Testing of cube:

In this phase we are going to test concrete cubes at 7 days, 21 days and 28 days.

Phase 7- Comparing result obtained by both conventional and software method:

In this phase after testing the cube, we are going to compare results of compressive strength to the software data.

Phase 8- Error analysis:

In this phase we are going to check how much fluctuation occurs in the result.

Phase 9- Result and Conclusion

Phase 10- Report preparation.

V. RESULT AND CONCLUSION

1) The use of ANN technique in the prediction of concrete mix proportions can be efficient and economical as it would reduce the need of preparing a large number of trial mixes, errors, labourers and time.

2) The mix proportion can be accurately predicted by using ANN method as compared to local experimental methods.

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