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Prediction of Concrete Mix Proportion Using Artificial Neural Network

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ABSTRACT: - Concrete mix design is complicated and time consuming, experience based and uncertain task. Most of the time to achieve the desired strength, one has to depend upon past experience in mix design process and some sort of trial and error methods the final acceptance come after quality control test results. In mix design min task is proportioning the ingredients of concrete (water , cement , coarse aggregates , fine aggregates) to chive desired strength. The ANN model is based on 7 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 labour. ANN gives higher accuracy. with the help of ANN we can predict of concrete mix for desired strength.
KEYWORDS: - Artificial neural network (ANN), concrete mix.

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I. INTRODUCTION

Concrete is the most commonly used building material. It has the advantage of being formed into any desired shape conveniently. The method of concrete mix predict consists of selection of optimum proportion of cement, fine and coarse aggregate and water to produce a concrete of specified proportion. Mix design in the strict sense of the word is not true: the materials used are variable in a number of respects and many of their properties cannot be assessed truly quantitatively, so that we are really making no more than an intelligent guess at the optimum combinations of the ingredient on the basis of the relationships established .Further, it is practically impossible to achieve the design strength of the mix in the field and what is realized in the field is somewhat around the design strength . Therefore, that in order to obtain a satisfactory mix we must check the estimate proportion of the mix by making trial mix and, if necessary, make appropriate adjustments to the proportion until a satisfactory mix has been obtained. In this paper artificial neural network (ANN) approach has been adapted to solve this problem.

II. FACTORS GOVERNING TO PREDICT CONCRETE MIX PROPORTION

Compressive strength is one of the most important properties of concrete and influences many other describable properties of the hardness or stiffness concrete. Because the strength of concrete is adversely and significantly affected by the presence of voids in the compacted mass, it is vital to achieve a maximum possible density of it.

A. Requirement of factor governing

This need a sufficient workability. Workability depends on a number of interacting parameters: water content, aggregate type and grading, aggregate/ cement ratio and finesse of cement. The desired workability also depends on the compacting equipment available at the site. The compressive strength tends to increase with the decrease in size of aggregate. IS 456:2000 & IS 1343:1980 recommend that the minor size of the aggregate should be as large as possible .

B. Condition for factor governing

The long life of concrete is its resistance to the aggressive atmospheric conditions. High strength concrete is generally more durable than low strength concrete. In the situations when the high strength is not necessary but the conditions of exposure are such that high durability is vital, the durability requirement will determine the water-cement ratio to be used. The standardization of aggregate also influences the mix proportions for a specified workability and water-cement ratio. Coarser the standardization leaner will be mix which can be used. The type of aggregate influences strongly the aggregate-cement ratio for the desired workability and stipulated water cement ratio. An prominent feature of an aggregate is the uniformity of the

scaling which can be achieved by mixing various size fractions. The degree of control can be estimated statistically by the according to changes in test results.

C. Strength deciding factor for governing

The grade of concrete refers to its characteristic strength. The concrete mix is designed for a target mean strength so that the concrete manufactured with an assumed degree of quality control confirms to the requirement of strength. The type of cement effect the rate of development of compressive strength of the concrete as well as durability under aggressive environment. High strength ordinary Portland cement is preferred for concrete of high compressive strength. Strength of concrete mix depends upon water/cement ratio. However, concrete. mixture having high cement content give rise to increase shrinkage effect. Cracking and creep of concrete also increase with increase in cement paste. Hence, proportion of cement should be optimum. The grading of aggregate influences the mix proportion for a desired strength and workability. The strength of a totally compacted concrete with a given water to cement ratio in independent of the grading of aggregate but it affects the workability of a concrete. The aggregate of coarser grading requires more fines to produce a cohesive concrete. Aggregate of grading affects quality as the total surface area increases, resulting in the requirement of more water. Since the combined aggregate is obtained by mixing fine and coarse aggregate in suitable proportion, the grading of both fine and coarse aggregate are important and should be controlled.

D. Method for concrete mix prediction

The Bureau of Indian Standards recommends a set of procedure for design of concrete mix . The following basic steps are involved in the mix design .

1) Determine the mean strength from the characteristic strength
2) Determine the water to cement ratio from strength requirement and check for the requirement of durability.
3) Determine water content from the requirement of workability.
4) Determine the cement content and check for the requirement of durability.
5) Determine the relative proportion of coarse and fine aggregates from their characteristics.
6) From the concrete mix proportion so obtained, trial mixes with suitable adjustments are made to arrive at the final mix proportions.

III. CONFIGURATION OF NEURAL NETWORK FOR PREDICTION OF CONCRETE PROPORTION

The artificial neural network modelled 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. the proposed concrete mix proportion pediction algorithm is expected to reduce the number of trial and error, save cost as economically beneficial, labourers and time consumption reduces overall cost.

A. 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.

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.

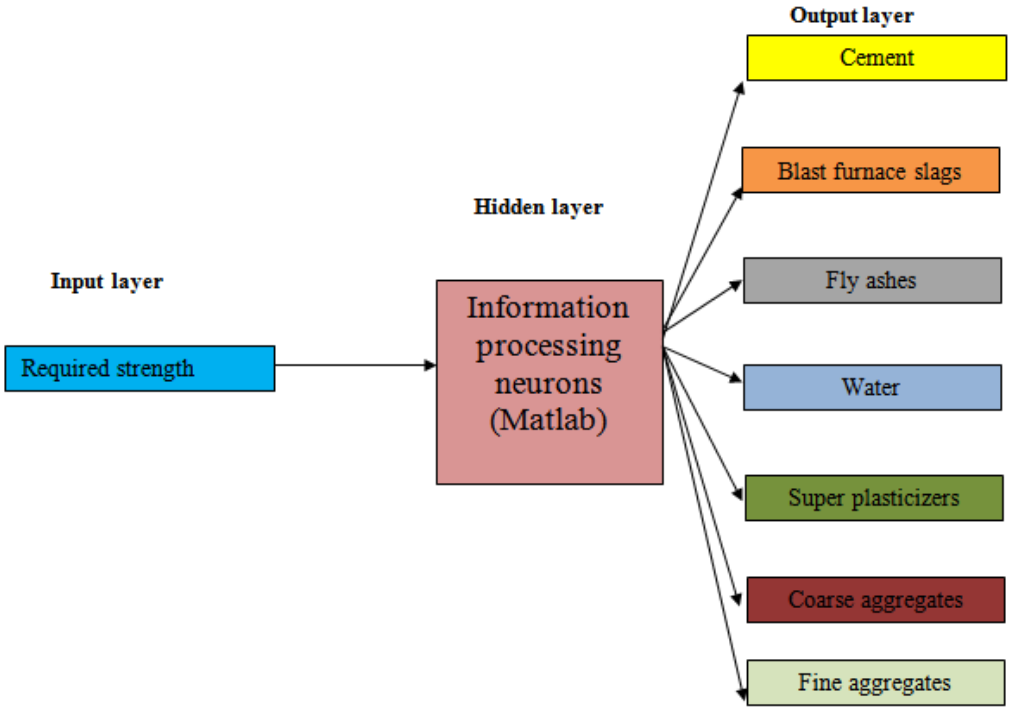

Fig 1. Neural network

B. ANN block diagram and design

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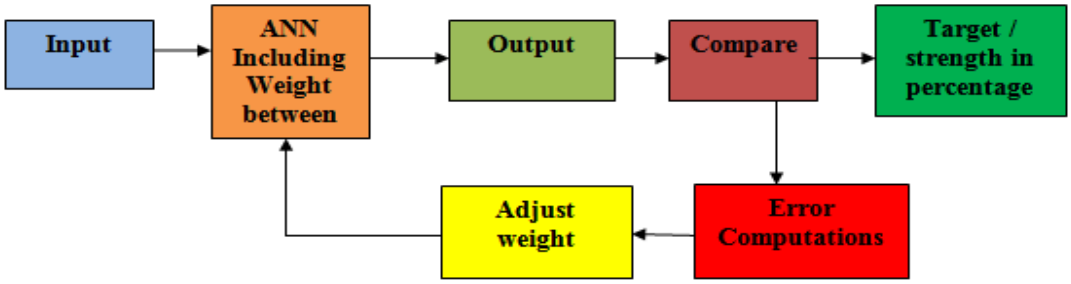

Fig 2. Neural network block diagram

C. Ratio proportion test and computed results

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. 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 & Mean absolute error is a quantity which is very commonly used to measure the accuracy of predicted values. The MAE takes measurement of the average magnitude of the errors in a set of forecasts, without taking an account of their direction. Proportion mix under test for 28 days duration & related strength results as follows.

Table I: Proportion mix table

Contents	**PROPORTION MIX (kg/m$^{3)}$**				
Cement	540	540	388	266	475
Blast furnace slags	0	0	95	114	0
Fly ashes	0	0	0	0	0
Water	162	162	228	288	228
Super plasticizers	2.5	2.5	0	0	0
Coarse aggregates	1040	1055	932	932	932
Fine aggregates	676	676	594	670	594
Age	28	28	28	28	28
Compressive strength	79.99	61.89	36.45	45.85	39.29

IV. CONCLUSIONS

The acceptance / rejection of the model developed are determined by its ability to predict the concrete mix proportion of desired compressive strength. Also, a successfully trained model is characterized by its ability to predict properties value for validation is used to predict the properties of compressive strength for the data set used in this study. The cross validation is the method of accuracy of a classification or regression model. The input data set is divided into several parts (a number defined by the user), with each part intern used to test a model fitted to the remaining part. The correlation coefficient, root mean square error (RMSE), and mean absolute error is used to decide the performance of the neural network approach in predicting the strength. Neural networks can be effective for analyzing a system containing a number of variables, to establish patterns and characteristics not previously known In the present study, Mix design of compressive strength using ANN using Neuron Solution Software has been carried out. The objective of this study is to predict various properties of compressive strength.

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