Prediction of Strength of Fly Ash Concrete

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Abstract— Concrete, being widely used, is the most important building material in civil engineering. Concrete is a highly complex material, which makes modeling its behavior a very difficult task. Many attempts were taken earlier to develop suitable mathematical models for the prediction of compressive strength of different concretes, but not for flyash concrete. Those traditional methods have failed to map non-linear behavior of concrete ingredients. The present study has used artificial neural networks (ANN) to predict the compressive strength of fly ash concrete. The ANN model has been developed and validated in this research using the mix proportioning and experimental strength data of 6 different mixes. The artificial neural networks (ANN) model is constructed trained and tested (in MATLAB) using the previous researches data. A total of 149 different fly ash concrete mix design were collected from technical literature. For comparative study, 4 models were developed. Strength was modeled in ANN-1 model as a function of three input variables: w/b, cement, water. ANN-2 model was presented with 4 input parameters: w/b (water-binder ratio), cement, water and fly ash%. ANN-3 model consist of 6 input variables: w/b (water-binder ratio), cement, water, fly ash%, coarse and fine aggregates. In this study, an attempt was also made to develop a multiple regression model for predicting strength (in EXCEL) as it is being used largely by researches in prediction. Finally, these four models were compared using coefficient of determination and RMSE values, and resulted in the fact that ANNs models have performed better than MLR model in predicting compressive strength of flyash concrete. Also, ANN model presented with more description of system (with more input variables that affect strength) yield more accurate results showing better correlation with observed/ experimented/actual strength.

Keywords: Fly Ash Concrete, Artificial Neural Network, Multiple Linear Regression

I. INTRODUCTION

Concrete is the most used and common building material all over the world. Its popularity is mainly because of its ability to flow and take any shape when presented in wet condition and acquire desired strength when it hardens. This material is produced by mixing water, cement, fine and coarse aggregate in additions to admixtures. The characteristics of concrete such as durability, strength etc. depend on ingredients properties, proportions of mix and other control measures like temperature level, curing period etc.

The wide use of concrete as the basic construction material may be due to its adaptability for a wide range of strength and workability. To achieve different strength requirements, it is the "Mix-design process" that makes the difference as the basic ingredients are same all the way. Very likely to other methods of Concrete Mix Design, Guidelines recommended by Bureau of Indian Standards for concrete mix design is based on certain empirical relations established through vast number of experiments conducted upon materials used in Indian conditions. IS:10262 is the specified code to serve the purpose. This code came to being in the year 1982. So IS:10262-1982 had been evolved to guide the concreting technology being followed at that period. But at present due to demand in high strength concrete and for economic production, use of supplementary materials has become essential. With the advanced technology a number of additives have been identified and are being used extensively now-a-days. These additives are not only enhancing the quality of concreting but also make the process economic and eco-friendly too. So keeping these in view the necessary modifications were felt essential and the revised version of the code as IS: 10262-2009-"Concrete Mix Design Guidelines" has met this in time. The revised version encourages use of supplementary cementitious materials and water reducing additives. Besides, being consistent with specifications of IS: 456- 2000, necessary modifications have been made. Data gathered for this present study (shown in Appendix-I) from previous researches is a collection of results obtained usingdifferent mix design procedures (as per IS codes 10262 old as well as new, ACI guidelines etc.). This study also takes an opportunity to study and compare the comparison between IS 10262:1982 and IS 10262:2009.

In this study, an attempt has been made to predict the 28th day compressive strength of flyash concrete using Artificial Neural Network (ANN)

II. OBJECTIVES OF THE STUDY

Various objectives of present project work have been to:

- Study concrete mix design procedures as per IS codes of practice (old as well as new)
- Study the effects of various factors/ parameters on compressive strength of concrete.
- Review on application of methods used for predicting compressive strength of concrete.
- Gather results from previous research works on fly ash concrete and prepare a worksheet for it.
- Develop ANN and MLR models from data collected to predict compressive strength
- Design concrete mixes for grade M40 and M45 (with varying fly ash percentages) in the laboratory for validation of those models.

Analysis results of ANN and MLR models in prediction and compare its results with experimental/ observed results obtained from laboratory.

III. LITERATURE REVIEW

A. Paperwork

In recent years, the analytical methods using artificial intelligence (AI) such as neural network and fuzzy logic have increasingly been applied to not only to predict concrete strength only but also in other engineering fields also. Qasrawi[35] presented that ANNs has strong potential as a feasible tool for predicting the compressive strength of concrete. In this study, model has been developed on the data collected from previous researches. They were:

Nagabhushana[12] aimed in observing the variation of strength of different grades of concrete with different levels of fly ash replacement. The objective of his study was to re- establish the findings of earlier research done in the area of fly ash concrete. The grades of concrete selected for the study were M20, M35 and M50. The fly ash replacements considered for the study are 0%, 20%, 35% and 50% of cement by weight. The results of study indicated that for M20 and M35 grades of concrete, there was increase in strength with 35% cement replacement by fly ash. For M50 grade of concrete, there was decrease in strength for all replacement levels selected for the study.

B. Prediction Methods to be compared

Artificial Neural Network (ANN)
Successfully employed in thermodynamics, flood and rainfall-runoff prediction, ground water monitoring, prediction of settlement of shallow foundation etc.
Developed in MATLAB
Multiple Linear Regression model (MLR)
Traditional method
A mathematical equation model
developed in MS-EXCEL
149 samples from 17 previous researches were collected
70 % used for training
15% used for validation

Input Parameters	Range
w/b	0.4-0.66
cement	55-600
Fly ash %	0-85
Water (kg/m^3)	103-204
Coarse aggregate Water (kg/m^3)	775-1277
Fine aggregate Water (kg/m^3)	491-937

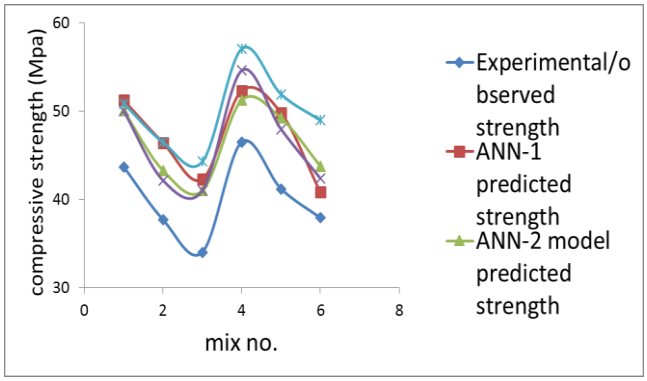
C. Multiple Linear Regression model

Model the relationship between two or more independent variables and a dependent variables by fitting a linear equation to observed data

$$\hat{y}=b_0 + b_1x_1 + b_2x_2 + \ldots + b_kx_k$$

Y = 44.81031 + 0.150993×(cement) + 0.308107×(flyash%) - 0.29603×(water)
Y : 28th day compressive strength of concrete (MPa)

D. Comparison



IV. CONCLUSION

ANN was found to be more accurate than the model based on regression analysis

ANN can be used for better understanding of non-linear interactions between various factors that decide the compressive strength of concrete

ANN-3 model (with 6 inputs) and ANN-2 (with 4 inputs) showed better results than ANN-1 model (with 3 inputs) that results were improved when network were provided with better description of the system To obtain higher accuracy, ANN models can be develop considering factors like age of concrete, curing conditions, temperature etc. as input parameters also

ANN model can be employed in predicting other characteristics of concrete like shrinkage, creep, its splitting tensile strength, flexural strength etc.)