PREDICTION OF 28-DAY COMPRESSIVE STRENGTH OF CONCRETE AT THE JOB SITE USING ANN

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ABSTRACT

This paper aims to predict the 28-day compressive strength of delivered concrete at the job site using ANN. The data sets that were used to construct the ANN model were obtained experimentally. Feature importance analysis and feature selection were employed to evaluate the significance of the input variables on the output variable and to improve the model prediction performance, respectively. The results demonstrated that the ANN model can predict the 28-day compressive strength of delivered concrete with high accuracy and robustness. It also indicated that the ANN model with feature selection outperformed the ANN model without feature selection. It was also discovered that the C/A ratio is the most important and influential feature of the model, followed by FA/CA ratio, ER, W/C ratio, slump, and temperature of delivered concrete.

METHODOLOGY

A. Experimental Work
- Formulation of concrete mixtures.
- Making and curing of concrete specimens.
- Conducting quality tests.
- Preparation of data sets.

B. Construction of ANN Model
- Selection of ANN architecture.
- Selection of other hyperparameters.
- Training and testing of the ANN model.

C. Perform feature importance analysis (FIA) and feature selection (FS) on the ANN model.

D. Comparison of the performance of the ANN model without feature selection with the ANN model with feature selection

8 Input Variables
- Ave. Electrical Resistivity
- Maximum Aggregate Size
- Fineness Modulus of FA
- Temperature of Concrete
- Slump
- W/C Ratio
- FA/CA Ratio
- C/A Ratio

1 Output Variable
- 28-day Compressive Strength of Delivered Concrete

CONCLUSIONS

The proposed ANN model can predict the 28-day compressive strength of delivered concrete with high accuracy and robustness. The results of feature importance analysis demonstrated that the C/A ratio is the most important and influential feature of the model, followed by FA/CA ratio, ER, W/C ratio, slump, and temperature of delivered concrete. The result of feature selection indicates that the maximum aggregate size and FM have feature importance scores below the selected threshold, hence, they were eliminated from the model. It was also found out that the ANN model with feature selection outperformed the ANN model without feature selection.

INTRODUCTION

Conducting a compressive strength test and waiting for 28 days for the results is time-consuming, cumbersome, and costly. However, ignoring the test can compromise the quality assurance of the concrete placed on the structure. Hence, researchers are motivated to explore fast and reliable methods to determine the compressive strength of concrete.

There are already existing ANN models that instantaneously and accurately predict the compressive strength of concrete with various compositions. However, almost all the prediction models available in the literature were only proposed for laboratory-sampled concrete and not for concrete that is delivered and sampled at the job site. These existing models have not captured the uncertainties during the transportation of concrete from laboratory or batching plant to the job sites in the development of their prediction models.

Hence, this study aims to address that gaps by developing an ANN model that predicts the 28-day compressive strength of delivered concrete at the job site. Since the water content and W/C ratio may vary due to several uncertainties, this study used the electrical resistivity (ER) of fresh concrete as one of the input variables which correlates to the actual W/C ratio of the delivered concrete. To the best of our knowledge, ER of fresh concrete has never been reported in the literature as an input variable of machine learning methods.

RESULTS AND DISCUSSIONS

Feature Importance Scores

Rank	Feature	Score
1	C/A Ratio	0.53803
2	FA/CA Ratio	0.20456
3	ER	0.11503
4	W/C Ratio	0.09468
5	Slump	0.03797
6	Temperature	0.01420
7	Maximum Aggregate Size	0.00001
8	FM	0.00000

FIA was performed using Permutation Feature Importance and the result indicates that the C/A ratio is the most significant. FS was also conducted with selected threshold equals to 1e-5.

Performance of model with 8 features

Statistical Parameters	28d Compressive Strength	
	Training Set	Testing Set
R	0.94478	0.94992
R^2	0.89260	0.90234
MAE	2.07494	1.99081
MSE	6.56378	5.99138

Performance of model with 6 features

Statistical Parameters	28d Compressive Strength	
	Training Set	Testing Set
R	0.95201	0.96598
R^2	0.90632	0.93312
MAE	1.92748	1.64211
MSE	5.72566	4.10324

The ANN model with FS outperformed the ANN model without FS.