Construction and Building Materials 400 (2023) 132604

Contents lists available at ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

Machine learning techniques and multi-scale models to evaluate the impact of silicon dioxide (SiO_2) and calcium oxide (CaO) in fly ash on the compressive strength of green concrete

Dilshad Kakasor Ismael Jaf [a,*], Payam Ismael Abdulrahman [b], Ahmed Salih Mohammed [c,d], Rawaz Kurda [e], Shaker M.A. Qaidi [f], Panagiotis G. Asteris [g,*]

[a] Civil Engineering Department, College of Engineering, Salahaddin University-Erbil, Kurdistan, Iraq
[b] Civil Engineering Department, College of Engineering, Tishk International University-Erbil, Erbil, Kurdistan Region, Iraq
[c] Civil Engineering Department, College of Engineering, University of Sulaimani, Kurdistan, Iraq
[d] The American University of Iraq, Sulaimani (AUIS), Sulaimani, Kurdistan Region. Iraq
[e] Department of Highway and Bridge Engineering, Technical Engineering College, Erbil Polytechnic University, Erbil 44001, Iraq
[f] Department of Civil Engineering, College of Engineering, University of Duhok, Duhok, Kurdistan-Region, Iraq
[g] Computational Mechanics Laboratory, School of Pedagogical and Technological Education, Athens, Greece

ARTICLE INFO

Keywords:
Artificial neural network
Concrete
CaO (%)
SiO_2 (%)
Fly Ash
Soft Computing

ABSTRACT

Fly ash is a by-product almost found in coal power plants; it is available worldwide. According to the hazardous impacts of cement on the environment, fly ash is known to be a suitable replacement for cement in concrete. A lot of carbon dioxide (CO_2) is released during cement manufacturing. The investigations estimate that about 8 – 10% of the total CO_2 emissions are maintained by cement production. Since fly ash has nearly the same chemical compounds as cement, it can be utilized as a suitable alternative to cement in concrete (green concrete). The current study analyzes the effect of the quantity of the two main components of fly ash, CaO, and SiO_2, on the compressive strength of concrete modified with different fly ash content for various mix proportions. For this purpose, various concrete samples modified with fly ash were collected from the literature (236 datasets), analyzed, and modeled using four different models; Full-quadratic (FQ), Nonlinear regression (NLR), Multi-linear regression (MLR), and Artificial neural network (ANN) model to predict the compressive strength of concrete with different geometry and size of the specimens. The accuracy of the models was evaluated using correlation coefficient (R^2), Mean absolute error (MAE), Root mean squared error (RMSE), Scatter Index (SI), a-20 index, and Objective function (OBJ). According to the modeling results, increasing SiO_2 (%) increased the compressive strength, while increasing CaO (%) increased compressive strength only when the cement replacement with fly ash was between 52 and –100%. Based on R^2, RMSE, and MAE, the ANN model was the most effective and accurate on predicting the compressive strength of concrete in different strength ranges. According to the sensitivity analysis, curing time is the most critical characteristic for predicting the compression strength of concrete using this database. The primary objective of this work is to explore and evaluate various machine-learning models for predicting compressive resistance. The study emphasizes these models' development, comparison, and performance assessment, highlighting their potential to predict compressive strength accurately. The research primarily uses machine learning, leveraging algorithms and techniques to build predictive models. The focus is on harnessing the power of data-driven approaches to improve the accuracy and reliability of compressive strength predictions.

1. Introduction

Cement production provides 8 to 10 % of the CO_2 emissions in the world [1]. Cement is an important factor that leads to greenhouse gases and global warming [2]. The key variables that lead to social and economic changes are industrialization, urbanization, globalization of the

* Corresponding authors.
E-mail addresses: dilshad.jaf@su.edu.krd (D. Kakasor Ismael Jaf), payam.ismael@alm.tiu.edu.iq (P. Ismael Abdulrahman), ahmed.mohammed@univsul.edu.iq (A. Salih Mohammed), rawaz.kurda@epu.edu.iq (R. Kurda), shaker.abdal@uod.ac (S.M.A. Qaidi), asteris@aspete.gr (P.G. Asteris).

https://doi.org/10.1016/j.conbuildmat.2023.132604
Received 19 February 2023; Received in revised form 7 July 2023; Accepted 23 July 2023
Available online 29 July 2023
0950-0618/© 2023 Elsevier Ltd. All rights reserved.