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PERFORMANCE OF ENGINEERING CEMENTITIOUS COMPOSITES

By

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ABSTRACT

Engineered Cementitious Composites (ECC) is a type of ultra-ductile cement-based composite material with supplementary materials reinforced with short randomly distributed fibers. It defers from Fiber Reinforced Concrete (FRC) in attaining unique ductile behavior.

The research aims to assign ECC mechanical properties such as tensile, flexural, and compressive strength with locally available fiber instead of polyvinyl alcohol (PVA) fiber as it is not available in many countries. Also, the cost of PVA fiber is very high. Lightweight fibers such as (Polypropylene, polyolefin, and glass fiber), and heavyweight fiber such as steel fiber were used instead of PVA. In this study, the influences of curing, fiber volume fraction (2%,4%, and 6%), fiber type, and fiber hybridization were adjusted to assess the mechanical properties.

The formation of multiple cracks along the specimen is the governing factor of ECC formation. Test results show improvement in flexural and tensile strength due to increasing fiber volume fraction. Water curing enhanced compressive strength, tensile strength, and flexural strength. Lightweight fiber hybridization is not effective for compressive strength, while hybridization of heavyweight fiber with lightweight fiber shows compressive strength enhancement. For tensile and flexural strength hybridization was associated with an improvement in all mechanical properties. Hybridization of lightweight fiber achieved ECC behavior at a lower volume fraction than the usage of a single fiber volume fraction. Relationships between tensile strength and flexural strength depending on the compressive strength of ECC were driven demonstrating high performance.

This research developed an artificial neural network (ANN) models to predict ECC mechanical properties such as compressive strength, flexural strength, and direct tensile stress-strain curve. ANN models were created, trained, validated, and tested based on a large data set with variable mix designs. The used data set was 151,76, and 44 test results for compressive strength, flexural strength, and direct tensile stress-strain curve collected from recently published research.

Models data analysis showed outstanding predictive performance with accepted accuracy of about 100%. Additional evaluation using an extra experimental data set confirmed the accuracy of the proposed ANN models with minimum relative errors around (0.15:9.40) % for compressive strength, (0.05:4.71) % for flexural strength and (1.40:5.00) % for the tensile strength. Based on the model's data analysis, additional data sets evaluation, and the statistical tools for the external data set including the absolute fraction of variance (R^2), and the degree of agreement (d) the models were capable of predicting the mechanical strengths of ECC mixtures. Finally, stress-strain relations can be predicted precisely using ANN models with a maximum variance of 7.10.