

Title: Predicting flexural properties of fiber reinforced composites: An experimental dataset analysis using machine learning models

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Abstract: Flexural behavior of fiber-reinforced composites (FRCs) is complex and the prediction of flexural properties is not very reliable because of this complex behavior of the material under bending loads. Destructive testing as a traditional characterization method is both expensive and time consuming, and the current models of predictive schemes can only be applied to single-fiber, but not hybrid systems. This paper fills the gap by building machine learning (ML) models to predict various flexural properties of pure and hybrid fiber systems. Fabrication of 54 laminates was done in pure and hybrids composition using carbon reinforcement, Kevlar reinforcement and glass reinforcement. The laminates were cross-ply stacked sequences and quasi-isotropic stacking sequence 4, 8, and 12 plies. The wide ranges of ML models were applied, such as baseline, neural network and ensemble models. Design parameters and testing conditions were used as input features to predict several flexural properties using these models which were trained, validated, and evaluated. The best flexural performance was experimentally found in the pure carbon cross 4 ply, carbon-glass cross 4 ply, and Kevlar-dominated tri-hybrid cross 4 ply (513.33 MPa, 519.72 MPa, and 349.39 MPa, respectively). Thickness and fabric weight were found to be the critical parameters to predict the desired outcome as K-Nearest Neighbors (KNN) became the best-performing model (MSE: 1044.53, MAE: 15.15, R^2 : 0.82), and Stochastic Gradient Boosting (SGB) with balanced ensemble performance (R^2 : 0.75) with thickness and fabric weight as critical parameters. The ANN was particularly weak in prediction (R^2 : 0.39) due to the size of the datasets. This research develops a strong ML model that predicts flexural characteristics in pure and hybrid fiber-reinforced structures which proves to be feasible to minimize the use of large-scale experimental studies.

Keywords: Fiber-reinforced composite Prediction Flexural properties Machine learning

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