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APPLICATIONS OF MACHINE LEARNING IN THE PREDICTION OF NONLINEAR BEHAVIOR AND FAILURE OF COMPOSITE MATERIALS

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This work aims to improve the representation of failure models in materials through computational methods. The increasing use of composite materials, due to their economic and structural advantages, requires more accurate constitutive and failure models. Traditional models (such as Tsai-Wu, Tsai-Hill, and Hashin) have limitations of polymeric composite failure modeling (such as delamination or matrix failure), which underscores the need for advanced computational approaches. For the concrete composite, widely used in civil engineering, nonlinearity is evident from the earliest stages of loading (such as cracking, yielding and finally crushing), which is not perfectly captured by traditional failure models (such as Kupfer and Otossen). Therefore, the application of advanced methods is essential to improve the modeling accuracy of both polymeric composites and concrete. The use of Machine Learning (ML) is proposed in this study to predict the onset of failure in laminated composites and capture the nonlinear behavior of concrete, represented by stress-strain curves. The work uses Artificial Neural Networks (ANN), combined with data augmentation techniques, to predict with greater accuracy the stress-strain curves of concrete in a biaxial stress-state, based on experimental data. Preliminary results indicate that it is possible to accurately model constitutive behavior directly from experimental data, without the need for complex idealizations of stress invariants. Failure prediction results of the investigated materials are presented to show the effectiveness of the use of ML in this area. The results show that ML can predict and represent nonlinear behavior very well by comparing the experimental stress-strain curves with those obtained by ML. In addition, ML was able to predict the Failure Surface (for any failure mode) of the concrete composite material.