Theoretical and Applied Fracture Mechanics
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Several machine learning models to estimate the effect of an acid environment on the effective fracture toughness of normal and reinforced concrete

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Highlights

- Presenting 12 ML models to predict the effective fracture toughness Keff of concrete.
- Evaluation of the ML models' performance in estimating the concrete's Keff compared to the CSNBD test.
- Investigating the effect of an acid environment on the Keff of normal and reinforced concretes.
- Performing sensitivity analysis on the database used to identify the most effective parameters on the concrete's Keff.
- Development of a graphical user interface tool based on the ML models to estimate the concrete's Keff.

Abstract

Crack extension and subsequent concrete fracture are regulated by the concrete's fracture toughness, making it an essential feature. Concrete, made from the most common and inexpensive building components, is the material of choice in civil engineering. Therefore, fractures and cracks may cause significant damage that may be impossible to repair. Furthermore, concrete constructions lose mechanical strength when encountering an acidic environment. This has led to the development of fiber-reinforced concrete, which addresses the issues. Therefore, studying the mechanical properties of concrete under different environmental conditions is of particular importance and should be considered in designs. For this purpose, in this study, the effect of an acid environment (PH=5) on the effective fracture toughness (Keff) of three types of concrete, including conventional concrete (CC), glass fiber-reinforced concrete (GFC), and glass fiber/microsilica-reinforced concrete (GFMSC), was investigated using the central straight notched Brazilian disc (CSNBD) test. Also, since conducting laboratory tests to obtain the Keff of concrete samples is time-consuming and costly, it is necessary to provide tools to estimate this concrete property with high accuracy in a short period and without the need for such a high cost. Using machine learning (ML)-based models was a suitable option to address such problems. For this purpose, twelve ML-based models were presented using 420 datasets generated from the CSNBD test to estimate the Keff of different concrete samples. The behavior of the ML models compared to the CSNBD test was investigated, and the correct and acceptable performance of each of them in estimating the Keff of concrete was confirmed. The CSNBD and ML results showed that an acid environment (PH=5) has a more destructive effect on the concrete's Keff than a neutral environment (PH=7). Also, reinforced concrete (GFC and GFMSC) is always more resistant to acid environments than normal concrete (CC). To further aid in the estimation of the concrete's Keff for engineering challenges, a graphical user interface (GUI) for the ML-based models was developed.