Shear Capacity Prediction of Ultra-High Performance Fiber Reinforced Concrete (UHPFRC) Beams using Machine Learning Techniques

R.S.S.A. Wijesundara*, K.R.T. Hemachandra, N.M.S.H. Bandara, K.K. Wijesundara

Faculty of Engineering, University of Peradeniya, 20400, Sri Lanka
**sandaruw@eng.pdn.ac.lk*

Ultra-High Performance Fiber Reinforced Concrete (UHPFRC) is a cutting-edge material known for its superior strength, durability, and versatility in structural applications. Its unique composition, including higher cement content, ultra-fine particles and high-strength steel fibers, contributes to exceptional mechanical properties. While UHPFRC finds applications in various structural elements such as bridges, prestressed elements, and building components, its widespread use is particularly notable in retrofitting elements due to these performance characteristics. Steel fibers in UHPFRC enhance both the shear capacity and ductility of elements, allowing for thin sections without shear reinforcement. In structural applications of deep beams, shear deformation becomes a critical consideration as the failure is primarily governed by shear forces. Thus, optimizing the shear capacity of deep beams becomes highly important and UHPFRC typically offers promising attributes in this regard. The accurate prediction of shear capacity and a detailed analysis of the factors influencing the shear strength of beams are paramount in structural and material engineering perspective. Despite experimental and numerical approaches being employed to explore the shear capacity of UHPFRC, still there is no robust and accurate method that considers the combined effect of all features due to the complex and non-linear nature of relationships between parameters. This research addresses this gap by leveraging Machine Learning (ML) techniques to develop a reliable prediction model for shear capacity estimation. For this, a comprehensive database was formed, incorporating material and performance characteristics gathered from the literature and a Gradient Boosting Regression (GBR) model was trained using this database. The final prediction model showed commendable accuracy with an R^2 value of 89.2%. Furthermore, a feature importance analysis was conducted to study the most influential parameters impacting the shear capacity of UHPFRC beams and the shear span-to-depth ratio and the shear reinforcement ratio emerged as the most critical parameters to the final outcome.

Keywords: UHPFRC, Shear Capacity, Machine Learning, Feature Importance

Acknowledgment: This research is funded by the University Research Grant (Grant No: URG/2023/16/E)