Development of an Ultra High Performance Fibre Reinforced Concrete (UHPFRC) Retrofitting Framework for Reinforced Concrete Beams

R.S.S.A. Wijesundara, I. Abeykoon*, N.M.S.H. Bandara, K.K. Wijesundara

University of Peradeniya, Peradeniya, 20400, Sri Lanka
**e18005@eng.pdn.ac.lk*

Ultra-High Performance Fibre Reinforced Concrete (UHPFRC) is a cementitious composite with superior mechanical properties, excellent durability, and abrasion resistance, making it well suited for structural retrofitting applications. The aim of this study is to develop an UHPFRC retrofitting framework for reinforced concrete deep beams employing two-sided jacketing. A shear-critical reinforced concrete deep beam with a span-to-depth ratio of 2 was selected as the control beam. A section analysis-based approach was employed to determine the flexure and shear capacities of UHPFRC retrofitted beams. Four jacket thicknesses of 10, 20, 30, and 40 mm were investigated. This range was selected to bracket the transition from shear-governed to flexure-governed behaviour, consistent with jacket thicknesses reported in the literature. The objective of the retrofitting design was to shift the brittle shear failure of the control beam to ductile flexure by using optimum UHPFRC jacket thickness, taken as the minimum thickness that produced a flexural failure. An experimental programme was conducted to validate the proposed retrofitting framework. An UHPFRC mix of 120 MPa compressive strength was developed using locally available raw materials with sufficient workability, and used to retrofit the control beam at the selected 40 mm optimum thickness. Contact between the UHPFRC jacket and the substrate was enhanced by chipping the beam surface. The control and retrofitted beams were tested under 3-point bending, and their load-displacement curves, failure modes, and crack patterns were compared. The 40 mm UHPFRC jacket increased the load-carrying capacity from 185 kN for the control beam to 376 kN, approximately doubling the capacity while shifting the failure mode from brittle shear to ductile flexure. In the control beam, diagonal shear cracks formed and propagated rapidly, causing failure at limited ductility. In the retrofitted beam, the UHPFRC jacket redistributed stress and suppressed diagonal cracking, promoting distributed flexural cracks and improved ductility. The analytically predicted ultimate load agreed closely with the experimental value, deviating by approximately 0.3%, confirming the accuracy of the framework. The study is limited to a single beam geometry and one surface preparation method. Future work should extend the validation to different geometries, jacketing configurations, and interface treatments.

Keywords: deep beams, retrofitting, shear capacity, UHPFRC, two-sided jacketing, section analysis, experimental validation

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