# Abstract

In environments of high moisture exposure, carbon fibre-reinforced polymer (CFRP) reinforcement is believed to be a good alternative to steel due to its non-corrosive properties. However the CFRP matrix experiences other types of changes, mechanical deterioration and transverse swelling, with exposure to moisture and sustained stresses. Specifically for structural applications, few studies have investigated the effects of moisture and stress-induced matrix-dominated changes to the CFRP-concrete bond when the CFRP rods are cast into concrete as prestressed reinforcement.

Experiments were conducted to measure the transverse swelling and moisture uptake rates of stressed and unstressed CFRP rods immersed in water and concrete pore solution (CPS). CFRP rods were also embedded in concrete and immersed in water to observe whether the transverse swelling of the rods would cause the concrete to crack. Pull-out tests were conducted on stressed and unstressed CFRP rods cast in concrete cubes and immersed in water for up to 125 days. Six CFRP prestressed concrete prisms were fabricated, three were immersed in water for over 125 days and three were left in lab conditions before being tested in three-point bending. Moisture-induced transverse swelling did not appear to cause cracking of the concrete covering CFRP rods in water, contrary to the prediction of the thick-walled cylinder model, but possibly caused an increase in the CFRP-concrete radial contact pressure. The imposition of sustained bending stresses on wet CFRP rods was found to cause premature failure, believed to be a result of matrix softening and microcracking. These observations of swelling and matrix degradation were believed to affect the CFRP-concrete bond. The pull-out tests of unstressed CFRP rods indicated an increased likelihood for bond failure in the CFRP matrix with moisture exposure. This resulted in greater variations in the ultimate and residual bond stresses of the wet samples compared to the dry controls. For the prestressed pull-out samples, higher magnitudes of prestressing resulted in lower bond failure loads. Both outcomes are indicative of matrix weakening with moisture and stress exposure. However despite this, the three-point bending tests revealed no significant differences in behaviour between the wet and dry prestressed prisms. Although the wet prisms exhibited slightly greater variation in their post peak load behaviour compared to the dry prisms, in line with the observations from the pull-out tests.

The work from this thesis reveals that despite observations of matrix deterioration and transverse swelling in CFRP rods exposed to moisture and stress, the effect of these changes to the overall behaviour of a CFRP prestressed concrete member are minimal. Any long-term effects are unlikely to cause significant changes to the behaviour of the member. However, the CFRP-concrete bond may be more variable in members exposed to moisture, which should be allowed for in the design process. Therefore CFRP is a promising alternative to steel reinforcement in high moisture environments, with good long-term durability.