# Abstract

Sometimes structures are not as strong as we would like. Demolishing and rebuilding structures is economically and environmentally costly. It is often desirable to strengthen an existing structure in situ. An option for strengthening reinforced concrete structures in shear is the use of externally bonded (EB) fibre reinforced polymer (FRP) fabrics. A common structural form that may require shear strengthening is that of a slab-on-beam structure. The presence of the slab means that an EB strengthening system cannot be fully wrapped around the beam. This commonly leads to a partial 'U-wrapping' of the accessible downstand beam. Design guidance exists for EB U-wrapped FRP strengthening systems but questions have been raised by a number of investigators as to the accuracy of existing models for the FRP strengthening effect. This thesis investigates the effectiveness of EB U-wrapped carbon fibre reinforced polymer (CFRP) strengthening.

Investigation of both local and global resistance mechanisms was identified as being important for understanding the influence of EB U-wrapped CFRP strengthening. Two test series were therefore carried out. The first investigated the local behaviour of a strengthened and unstrengthened interface in reinforced concrete through the development of a novel modified push-off test. This investigation showed that peak concrete, steel and CFRP forces did not generally coincide; that EB CFRP can increase the cracking load of the concrete; and that prescribed CFRP anchorage lengths may not be sufficient to realise the CFRP contribution estimated by design guidance. The second test series investigated the behaviour of a series of different sized, geometrically scaled reinforced concrete T-beams with transverse reinforcement, and with and without EB U-wrapped CFRP strengthening. Multiple control specimens were tested. Significant variability was observed in the behaviour of some nominally identical unstrengthened control beams. CFRP strengthened beams were observed to attain peak loads higher than the weaker unstrengthened control beams but lower than the stronger unstrengthened control beams. This indicates that, for the beams tested, the 'strengthening' effect was less than the variability associated with the behaviour of the underlying beam.

The theory of plasticity for cracked and uncracked concrete was used to understand the behaviour of both the push-off tests and the T-beam tests. The push-off test results were shown to provide new experimental validation of the plastic theory for interfaces in the presence of shear and tension. Plasticity theory was also shown to provide a coherent explanation of the variability of the underlying beam behaviour. A plastic approach based solely on underlying beam behaviour is shown to provide better predictions of strengthened beam behaviour than a number of existing design models. A new limit on strengthened beam capacity is proposed based on the theory of plasticity.