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Shear Retrofitting of Reinforced Concrete Beams with CFRP Straps
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A technique has been developed that employs thin Carbon Fibre Reinforced Polymer (CFRP) straps for shear enhancement of RC beams. Previous studies using these straps have employed steel pads on top of the beam to support the strap but this is problematic from a practical point of view. The initial goal of this research was to develop a method of installing the straps without requiring access to the top surface of the slab that still provided effective shear enhancement, thus reducing the costs associated with repair.

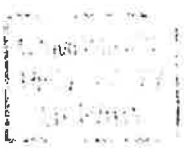
This novel strap installation method was developed through a series of tensile tests on the straps. It was found that the straps must be kept away from the sharp edges of the concrete, that the strap cross section must be kept flat, and that the material supporting the strap must be sufficiently stiff.

Seven T-beam tests were performed to develop a strap configuration that maximized the shear enhancement but could also be installed from under the slab. The chosen installation technique involved drilling holes in the flange and then filling the holes with grout except for a small groove to support the strap. To ensure maximum enhancement, the straps need to fully penetrate the compression flange of the beam and the amount of flange area removed for the straps should be minimized. The shear capacity is also affected by the size of the loading pad.

A Finite Element Analysis (FEA) determined that holes in the flange act as crack propagators, strap penetration affects the stiffness of the beam and undersized load pads allow shear cracks to form on lower energy paths.

Code equations were developed by comparing the predictions of existing shear models using the straps. The most accurate model, a shear friction approach, was then used to develop a retrofit design procedure for use with the straps.

To evaluate the long-term performance of the straps and the under-slab installation technique two further T-beam tests were undertaken: a sustained load test where the beam was loaded to 80% of its retrofitted capacity for 260 days and a cyclic test where the load was varied between 50 and 80% of the retrofitted capacity for 2.1 million cycles. In both cases the straps withstood the loading. However, the strains in the straps increased over time, an important observation considering the brittle CFRP straps, which led to the development of a model to predict the long-term strap strains.



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