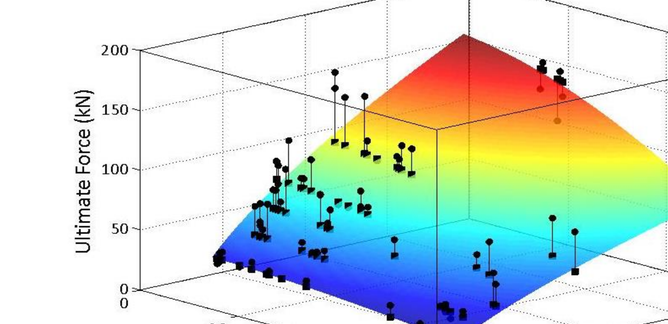
Enrique del Rey Castillo, *PhD candidate (edel146@aucklanduni.ac.nz)*
Jason M. Ingham, *Professor of Structural Engineering & QuakeCoRE Flagship Leader*
Michael Griffith, *Professor of Structural Engineering*

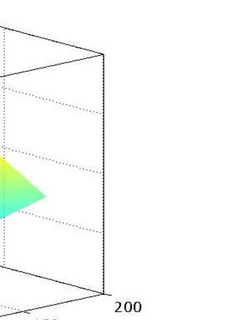
SEISMIC STRENGTHENING OF REINFORCED CONCRETE COLUMNS WITH STRAIGHT CARBON FIBRE REINFORCED POLYMER (CFRP) ANCHORS

Poster 030

EBR-FRP systems with FRP anchors

Externally Bonded Fibre Reinforced Polymer Reinforcement (EBR-FRP) systems are an effective technique to improve the behaviour of existing buildings. The main drawbacks are the premature FRP-to-concrete debonding or the presence of other structural elements such as slabs or walls. A method to overcome these problems involves the use of FRP anchors, which can be inserted bent or straight into the structure. FRP anchors consist of a bundle of fibres having one end splayed out in a circle or fan shape and bonded to the FRP sheet and the other end of the bundle being embedded with epoxy resin into a hole that is pre-drilled into the RC structure.





Predictive equation

A force-based predictive equation for straight FRP anchors was developed from the results obtained in an experimental campaign with component tests, considering the anchor size (dowel area) and the fanning angle α. This equation controls the fibre rupture failure mode, which completes the model previously developed for other failure modes (Kim & Smith 2010, Pull-out Strength Models for FRP Anchors in Uncracked Concrete).

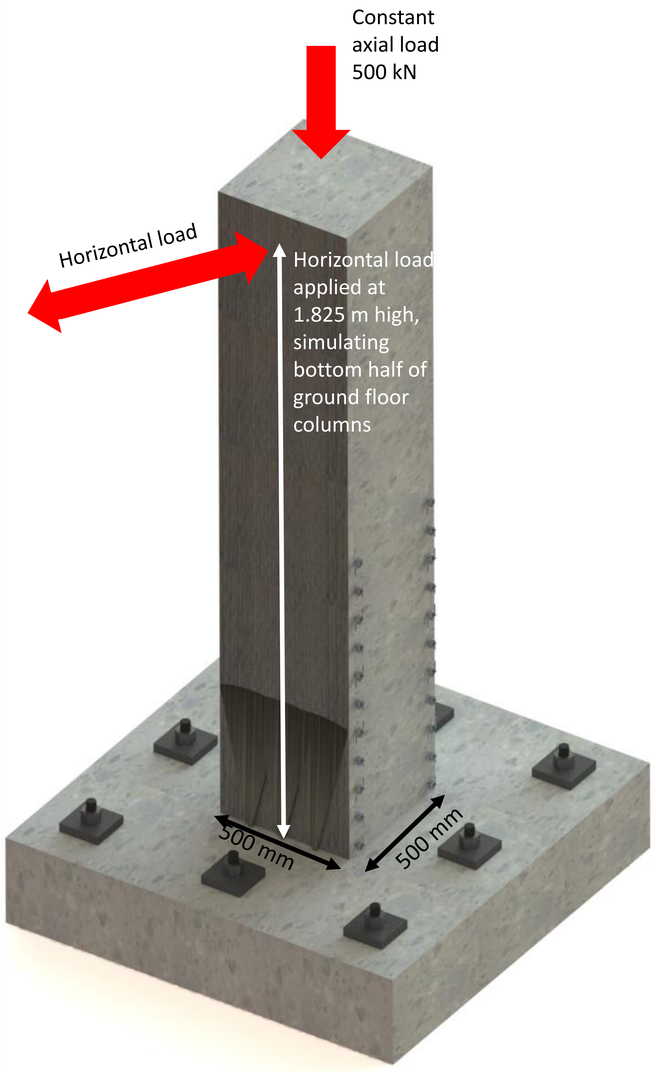
$$N_{fr} = 2.9\sigma_{FRP}\cos(0.57\alpha_0)A_{dowel}^{2/3}$$

$$N_{fr}^{95\%} = \sigma_{FRP}\cos(0.57\alpha)(2.9A_{dowel}^{2/3} - 1.2A_{dowel}^{-1/3})$$

3D model representation of predictive equation

A 3D representation of the design equation can be seen below, with the data points shown as circles and their predicted load shown as squares.

The specimens have been built, and will be tested within the next weeks.



Test matrix

Six specimens will be tested:

1. As-built
2. Three anchors with a cross sectional area of 84 mm² un-confined
3. Three anchors with a cross sectional area of 84 mm² confined
4. Three anchors with a cross sectional area of 186 mm² un-confined
5. Three anchors with a cross sectional area of 186 mm² confined
6. Three anchors with a cross sectional area of 186 mm² confined subjected to dynamic load

Why flexural strengthening of RC columns?

After consulting key members of the industry (BBR ConTech, Opus International, Fulton Hogan and Beca) it was found that, while the most common failure of RC columns is shear failure, the shear strengthening of RC columns with FRP anchors is fairly well known by engineers, and they are confident in their design. Flexural strengthening of RC columns with FRP anchors is a complex and unknown application and only one example of a research focused on this technique could be found in the existing literature.

Main objectives

In addition to verify the applicability of the design equation previously developed, a few aspects not covered in the component tests will be investigated:

- The effect of tensile-compression cycles
- The effect of dynamic loading
- The interaction between adjacent anchors
- The behaviour of edge anchors
- The effect of overlapped fan components
- Behaviour on real case specimen
- Effect of different confinement schemes
- Effect of different anchor sizes
- Strengthening of columns with lap splice failure