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Case Study

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TOWARDS A MECHANICAL ANCHOR SYSTEM FOR CFRP PLATES

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1 Introduction

For prestressed carbon fibre-reinforced-polymer (CFRP) plates, a special end-anchor is required in order to transfer the forces from the CFRP plate to the concrete beam or slab surface to avoid premature peeling-off failure in the CFRP plate. Since CFRP plate has a relatively low transverse compressive strength, the traditional anchors and clamping used for steel plates can crush CFRP at its load bearing area, leading to premature failure of the CFRP plates at the anchorage point. Without an anchor, the full tensile capacity of CFRP plates is not utilized. In order to utilize the full capacity of its ultimate tensile strength, prestressing an easy-to-install anchor is required. This article deals with the development, analysis, parametric study and experimental investigation of an innovative, easy-to-install, low cost, epoxy-free, mechanical, compact, high-strength, prestressing anchor for the CFRP plates. The anchor was developed to prestress the popular and commercially available high-strength CFRP plates. The novel CFRP plate anchor was designed and analyzed by means of finite element numerical modelling.

2 Project Overview

The invention of an innovative, mechanical, epoxy-free, short, cost-effective and high-strength anchor, having no premature failure or slippage of the plate from the anchor under a 2,800 MPa tension load, was required to grip and prestress the CFRP plates; and undertaken in this research.

This research focused on the development of an epoxy-free, mechanical, friction-based anchor for the CFRP plates. The new anchors were developed for the popular 50 mm wide and 1.2-1.4 mm thick CFRP plates. These new anchors were developed primarily for new construction and structural repair, rehabilitation and retrofitting of aging infrastructure. The research work focused on the experimental investigation of the friction characteristics between the CFRP plate and the sleeve material, and the finite element based numerical modelling and the parametric study of the anchors.

3 Innovation

The innovation of the novel, mechanical, epoxy-free and high-strength anchorage system for the 1.2 mm thick CFRP plate with high tensile strength of 2,800 MPa that can carry the full strength of the CFRP plate.

4 Lessons Learned

The lessons learned from the friction tests towards the development of the new anchor are:

- The frictional behaviour of CFRP plates in contact with as-received and annealed copper plates was characterized experimentally within the contact pressure range of 50-175 MPa.

- Within the 50-175 MPa contact pressure range, the static coefficient of friction between the CFRP plate and the as-received copper plate was found as 0.31.
- The static coefficient of friction between the CFRP plate and the annealed copper plate decreased from 0.39 to 0.30 with the increase of contact pressure from 50 MPa to 175 MPa.
- The softer annealed copper plates exhibited a higher coefficient of friction value (0.30-0.39) than the harder as-received copper plates (0.30-0.31) in the 50-175 MPa contact pressure range.
- For the as-received copper plate, the shear stress vs. normal stress (contact pressure) relationship obtained at the contact pressure range of 50 MPa-175 MPa was: $\tau = 0.31\sigma$.
- For the annealed copper plate, the shear stress vs. normal stress relationship obtained at the contact pressure range of 50 MPa-175 MPa was: $\tau = 1.02\,\sigma^{0.76}$.

The lessons learned from the finite element modelling (FEM)-based Numerical Modelling are as follows:

- Finite element numerical model of the new anchor was developed.
- There was no slip of the CFRP plate from the anchor under 2,800 MPa tension load.
- Based on the numerical model results, in all anchor components, the maximum contact pressure was at the pre-setting end and the minimum contact pressure was at the tension load end of the anchor.
- The longitudinal profile radius of the barrel and the wedge, the length of the barrel and the wedge, the thickness of the barrel and the wedge, the pre-setting distance and the interference distance between the barrel and the wedge at the loading end had significant effects on the anchor performance.

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