World Journal of Engineering 7(4) (2010) 163-171

World Journal of
Engineering

Stress transfer and crack propagation of FRP-to-concrete bonded joints with end anchorage

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Abstract

External bonding of fiber reinforced polymer (FRP) composites has become a popular technique for strengthening concrete structures all over the world. The performance of the interface between FRP and concrete is one of the key factors affecting the behavior of the strengthened structure, and can be studied using simple shear tests on FRP plate/sheet-to-concrete bonded joints. While a great deal of research is now available on the behavior of these bonded joints, only stress boundary conditions are considered and no closed-form analytical solution has been presented which is capable of predicting the entire debonding propagation process of realistic existing FRP-to-concrete joints with end anchorage. This paper presents such an analytical solution, in which the realistic bi-linear local bond-slip law and end anchorage boundary conditions are employed. Expressions for the interfacial shear stress distribution and load-displacement response are derived for different loading stages. Finally, the analytical solution of FRP-to-concrete bonded joints with end anchorage is compared with that of the joints with free end, and some valuable conclusions are obtained.

Key words: *FRP, Concrete, Anchorage, Interface, Debonding*

1. Introduction

Many structures need strengthening all over the world for various reasons such as ageing, change of function and design and construction errors. Steel plates have been used since 1960s but fibre reinforced polymer (FRP) plates have gradually replaced steel plates over the last decade and are now much more popular than steel plates because of their superior properties such as a high strength-to-density ratio and excellent corrosion resistance. FRP plates have been used to strengthen not only reinforced concrete (RC) but also metallic, masonry and timber structures. The success of the technique relies on the effective stress transfer between the external plate and the surface layer of the existing structure (i.e. the substrate) through an adhesive layer. The bond behaviour between the plate and the substrate is thus of critical importance.

FRP -strengthened concrete structures with plate or sheet bonding technique, when loaded in bending and shearing, can fail in several ways and show very complicated failure phenomena. In order to obtain the sufficient strengthening effects, the strengthened structures must be properly designed to avoid premature failures due to debonding and peeling-off of the strengthening laminates. Due to the brittle behavior of interfacial fracture,

ISSN:1708-5284