Efficiency of adhesive layers in strengthening schemes of concrete elements

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Abstract

This study quantifies the efficiency of different type of adhesive layers of strengthening schemes for concrete elements. Two different Carbon Fiber Reinforced Polymer (CFRP) types are examined: a) laminated sheets and b) prefabricated plates. The systems were integrated onto concrete substrates using adhesives: i) standard plate epoxy, ii) epoxy of dry impegnation and iii) toughened adhesive. The interface response was investigated experimentally with double-lap shear tests. The efficiency was quantified with a novel semi-empirical proposed index, IC (interface capacity), representing the failure mechanism and the response type. Values close to 1 denotes a linear fully elastic performance leading to abrupt brittle failure whereas, higher values correspond to more plastic response and progressive debonding. The experimental results validated finite element simulations to define the values of IC, matching the shear response and the failure pattern of the CFRP system.

Keywords: FRPs, toughened epoxy layers, rubber-like nanoparticles, prediction model, strengthening schemes.

1 Introduction

During the last four decades, the development of advanced composites materials have resulted in structural solutions as passive retrofitting measures enhancing strength and ductility [1], [2]. This is mainly due to their outstanding properties such as e.g. high tensile strength, low density, high fatigue endurance, high damping and low thermal coefficient.

The FRP systems consist of the FRP type and an adhesion layer of polymeric base. The polymer most widely used in structural applications is epoxy [3] demanding have high durability against exposure in moisture or extreme corrosive or temperature conditions and to UV radiation [4]. This exposure of the application affects negatively the bond and shear strength up to 30% and therefor the stiffness of the system, resulting to premature failures of adhesion-cohesion type [5]. The failures depend on the substrate condition, the type of measure, the adhesion layer chosen and the crack propagation at the structural element, making the efficiency of the measure to range.

The novel concept of curing epoxies to enhance the shear performance is to incorporate nanoparticles, such as rubber like particles [6] into the epoxy matrix, altering the properties. They permit dislocations and crack propagation at the matrix mass, absorbing more energy before failure.

The overall effectiveness of such strengthening schemes is quantified by the proposed model, taking into consideration the load transfer to the composite and the failure propagation of the substrate. The study includes two different different Carbon Fiber Reinforced Polymer (CFRP)