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# Effect of air bubbles in concrete on the mechanical behavior of RC beams strengthened in flexion by externally bonded FRP plates under uniformly distributed loading

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**Abstract.** This article presents a theoretical study taking into account the effect of air bubbles in concrete (as a material manufacturing defect) on interfacial stresses, in reinforced concrete beams, strengthening with an externally bonded FRP composite plate. Both even distribution and uneven distribution of the air bubbles are taken into account and the effective properties of RC beams with air bubbles are defined by theoretical formula with an additional term of porosity. In particular, reliable evaluation of the adhesive shear stress and of the stress in the composite plates is mandatory in order to predict the beam's failure load. The model is based on equilibrium and deformations compatibility requirements in and all parts of the strengthened beam, i.e. the concrete beam, the FRP plate and the adhesive layer. Numerical results from the present analysis are presented both to demonstrate the advantages of the present solution over existing ones and to illustrate the main characteristics of interfacial stress distributions. This research is helpful for the understanding on mechanical behaviour of the interface and design of the hybrid structures.

**Keywords:** imperfect RC beam; air bubbles, interfacial stresses; strengthening; composite plates

## 1. Introduction

Among the new construction techniques, the rehabilitation of existing structures using composite materials is an effective solution to deal with certain natural phenomena. The purpose of this paper is the study of the phenomenon of separation of the composite plate, due to the high interface stresses at the edge of the plate bonded in a reinforced concrete beam strengthening with composite materials (Tounsi 2006). In recent years, several research studies have been carried out on the rehabilitation method (Abualnour *et al*. 2019, Hassaine Daouadji *et al*. 2016, 2019, Sharif *et al*. 2020, Antar *et al*. 2019, Benyoucef *et al*. 2007, Rabia *et al*. 2019, Bensattalah *et al*. 2016, 2018, Abdederak *et al*. 2018, Abdelhak *et al*. 2016, Belkacem *et al*. 2016, 2018, Daouadji and Adim 2016a, b, Hamrat *et al*. 2020, Hassaine Daouadji 2013, 2017, Hadj *et al*. 2019, Mahi *et al*. 2014, Guenaneche *et al*. 2014, Krour *et al*. 2014, Mohammadimehr *et al*. 2018, Panjehpour *et al*. 2014, Rabahi *et al*. 2019, Smith and Teng 2002, Tounsi 2006, Yeghnem *et al*. 2019, Bouakaz *et al*. 2014, Chedad *et al*. 2018, Chergui *et al*. 2019, Zidour *et al*. 2020, Benhenni *et al*. 2019a, Benferhat *et al*. 2016, Zine *et al*. 2020).

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