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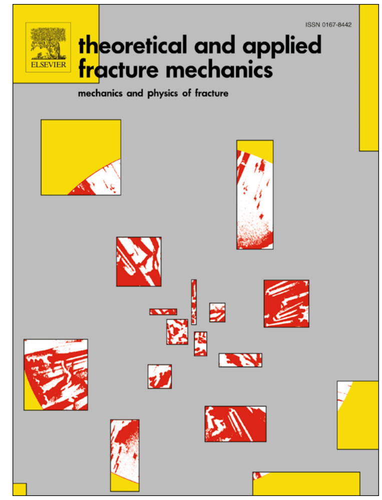

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On the strength prediction of adhesively bonded FRP-steel joints using cohesive zone modelling

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ABSTRACT

The variety of failure modes that are likely to occur in fibre-reinforced polymer (FRP)/steel joints used in the construction industry adds to the complexity associated with the design of these joints. This variation in possible failure modes is mainly attributed to the lack of a controlled application environment and to rather insufficient quality assurance protocols and procedures. The use of energy-based methods such as, cohesive zone modelling (CZM), can be a solution to circumvent such complexities. This paper investigates a number of issues related to CZM analyses of FRP/steel adhesive joints using various test configurations and a comprehensive numerical study. Parameters such as the effect of shape and type of cohesive law, crack path location, length of damage process zone, variations of adhesive and FRP properties, and different failure modes including cohesive, interfacial debonding and FRP failure on the strength of joints are investigated. The results show that the behaviour of the tested joints is accurately predicted provided that the variation of failure modes are taken into account. Moreover, it is shown that the damage process zone in adhesive layer is directly proportional to the shape of cohesive laws. This feature can be employed in the design phase to ensure sufficient overlap length and to account for important in-service parameters such as temperature and moisture.

Keywords: cohesive zone modelling; interface fracture; crack growth; composites; fibre reinforced materials; civil engineering structures.

1. Introduction

Using bonded fibre-reinforced polymer, FRP, laminates for strengthening and repairing structures offers many advantages in comparison to traditional strengthening methods [1–5]. Carbon fibre-reinforced polymer, CFRP, laminates have been used in practice to strengthen and repair concrete structures for almost four decades [6]. In the past few years, there has also been a trend towards using the FRP bonding technique to strengthen and repair steel [1,7] and timber structures [8]. The effectiveness of the strengthening and repair of structural steel members with bonded FRP laminates has been demonstrated in a number of theoretical and experimental studies (see, for example, [9–12]). In addition to strengthening and repair, FRP materials have found their way into whole- and partial-FRP structures, e.g. using glass fibre-reinforced polymer, GFRP, deck systems on steel girders for the construction of hybrid FRP bridges or the refurbishment of existing steel bridges. As a result, there is a great deal of interest in studying the behaviour of FRP-steel adhesive joints from the short- and long-term behaviour perspectives.

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