Accepted Manuscript

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PII: S1359-8368(18)30280-4
DOI: 10.1016/j.compositesb.2018.02.032
Reference: JCOMB 5557

To appear in: *Composites Part B*

Received Date: 23 January 2018
Revised Date: 20 February 2018
Accepted Date: 27 February 2018

Please cite this article as: Orefice A, Mancusi G, Berardi VP, Feo L, Zuccaro G, Residual stiffness of bonded joints for fibre-reinforced polymer profiles, *Composites Part B* (2018), doi: 10.1016/j.compositesb.2018.02.032.

Residual Stiffness of Bonded Joints for Fibre-Reinforced Polymer Profiles

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Abstract: In this paper we present an experimental study on the behaviour of samples concerning double lap joints made of glass fibre-reinforced polymer composite (GFRP). According to a multistep displacement/force control procedure, a data driven approach is performed with the aim of investigating the behaviuor of adhesive joints between GFRP profiles at service conditions focusing on the non-linearity of the interfacial damage as the number of cycles increases. The present analysis has been performed regardless of the consideration of material/geometric non-linearities, which affect, instead, the failure load or the buckling limit for higher loads. The final results provides a database for sketching a predictive rule to be used for a direct evaluation of the loss of stiffness of the joint.

Keywords: fibre-reinforced polymers; double lap-joint; cyclic behaviour; Service Limit State.

1. Introduction

Composite profiles made of glass fibers (GFRP) are commonly used for civil engineering structures. Within this context their use still surpass the use of carbon fibre-reinforced profiles (CFRP) due to a minor cost. Thereby GFRP profiles are, at the moment, the standard solution for new innovative civil constructions and large scale applications. For these innovative structures the design of connections requires more caution. This is true expecially for the case of adhesive bonding, which represents a field of investigation still open to both theoretical-numerical and experimental contributions [1–8].

Many factors are relevant on the behaviour of adhesive joints, both at the failure point and at service conditions: the thickness and width of the adherents, the number of lap surfaces and the scarf angle (for scarf lap-joints). A recent study about adhesive bonded joints loaded in traction [9] focuses, in a general manner, on this topic.

Although they are widely used in technical practice, adhesive joints for applications of major importance (large truss covers, large bridge decks, or spatial frames) are generally discouraged by the lack of knowledge about their safety and reliability.

The non accuracy of linear models for capturing the mechnical response is the first aspect to be examined. Infact, although the constitutive behaviour of composite materials is usually formulated within a linear-elastic (orthotropic) field, relevant nonlinear effects may emerge over the pre-failure range of the structural response, due to many factors:

- the coupling between axial, flexural, shear, and warping deformations [10–13];
- the time-dependent (delayed) behaviour of GFRP members under dead loads [14–16];
- the "lumped" damage within the bonding interfaces [17-18].