8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

FINITE ELEMENT ANALYSIS ON THE MECHANICAL BEHAVIOUR OF ADHESIVE LAP JOINTS

***Francesco Ascione[1], Geminiano Mancusi [2]**

[1] University of Rome "Tor Vergata"
Via del Politecnico 1, ROMA
ascione@ing.uniroma2.it

[2] University of Salerno
Via Ponte don Melillo, FISCIANO (SA)
g.mancusi@unisa.it

Key Words: *Adhesive joints, Cohesive fracture, FRP, FEM.*

ABSTRACT

Adhesive lap joints for structural purposes are well known in many sectors of Engineering, above all in the Aeronautical and Mechanical fields, mainly due to the strong reduction of both time and construction cost given by their use. Other benefits are represented by the resistance to corrosion and fatigue as well as the toughness with regard to the fracture. In recent years, adhesive lap joints are going to diffuse themselves also in the field of Civil Engineering, in particular regarding the applications of FRP (Fibre-Reinforced Polymer) structural members.

The modern theoretical approaches in studying the mechanical behaviour of adhesive lap joints refers to Fracture Mechanics and follows two main lines: the first one is based on the classical Griffith criterion (Linear Elastic Fracture Mechanics), while the second one is based on appropriate models of interfacial laws (cohesive constitutive laws) between adherents and adhesive.

The main limit of the first line is represented by the hypothesis of linear elastic behaviour required to adherents and adhesive up to the fracture. In fact, when dealing with adhesive lap joints made of FRP, the aforementioned hypothesis is certainly satisfied by the adherents, but it is certainly not appropriate for the adhesive.

A theoretical and numerical analysis on the equilibrium problem of FRP adhesive lap joints, has been recently developed using cohesive interfacial laws [14-15]. In particular, bilinear interfacial laws have been considered, composed of a linear elastic branch followed by a decreasing range, linear too, which corresponds to a softening behaviour of the adhesive. No shear deformability as well as no coupling between extensional and flexure behaviour of the adherents have been taken into account. Furthermore, only a pseudo-interaction between fracture modes I and II has been considered, by using the Hutchinson and Suo fracture criterion [4].

The aim of the present paper is to extend the above mentioned analysis accounting for the shear deformability of the adherents and the coupling between extensional and flexure equilibrium problems. The numerical results, obtained via finite element simulations, will be compared with the results obtained in [14,15] and with the most recent results available in literature.

REFERENCES

[1] Hart-Smith LJ., "Design of adhesively bonded joints. Joining fiber-reinforced plastics", Matthews FL Editor. Elsevier Applied Science, pp. 271–311, (1987).

[2] Bigwood D. A. and Crocombe A. D., "Elastic analysis and engineering design formulae for bonded joints", Int. J. Adhesion and adhesive 9(4), pp. 229-242, (1989).

[3] Wang J.S. and Suo Z., "Experimental determination of interfacial toughness using Brazil-nut-sandwich", Acta Metallurgica, vol. 38, pp. 1279-1290 (1990).

[4] Hutchinson J.W. and Suo Z., "Mixed-mode cracking in layered materials", Advances in Applied Mechanics, vol. 29, pp. 63-191 (1992).

[5] Tsai M. Y. and Morton J., "An experimental investigation of nonlinear deformations in single-lap joints", Mechanics of Materials, vol. 20, pp. 183-194, (1995).

[6] Tsai MY, Oplinger DW and Morton J., "Improved theoretical solutions for adhesive lap joints", Int Journal of Solids Structures, vol. 35(12), pp.1163–85, (1998).

[7] Yang Q. D., Thouless M. D. and Ward S. M., "Numerical simulation of adhesively-bonded beams failing with extensive plastic deformation", Journal of Mechanics and Physics of Solids, vol. 47, pp. 1337-1353, (1999).

[8] Keller T., "Recent all-composite and hybrid fiber reinforced polymer bridges and buildings", Progress Struct Eng Mater, 3/2, pp.132–40, (2001).

[9] Hart-Smith LJ., "Adhesive bonding of composite structures—progress to date and some remaining challenges", J Compos Technol Res, vol. 24(3), pp. 133–53, (2002).

[10] Sorensen F. B. and Jacobsen T. K., "Determination of cohesive law by the J integral approach", Engineering Fracture Mechanics, vol. 70, pp. 1841-1858, (2003).

[11] Bennati S., Calleluori M., Corigliano D. and Valvo S. P., "Frattura interlaminare secondo il modo I in un laminato composito", Atti del Convegno Aimeta, (2005).

[12] Li S., Thouless M. D., Waas A. M., Schroeder J. A. and Zavattieri P. D., "Use of mode-I cohesive-zone models to describe the fracture of an adhesively-bonded polymer-matrix composite", Composite Science and Technology, vol. 65, pp. 281-293, (2005).

[13] Aymerich F., Dore F., Meloni D. and Priolo P., "Modellazione del danneggiamento da impatto in laminati compositi mediante elementi coesivi", Atti XXXV Convegno AIAS, (2006).

[14] Ascione F., "Mechanical behaviour of adhesive lap joints", Atti del convegno Aimeta, (2007).

[15] Ascione F., "Modellazione di giunti di FRP", PhD. thesis at University of Rome "Tor Vergata", (2008).