Evaluation of Compliance Methods Applied to Fatigue Analysis for Bonded Joints Under Mode I

Denys Marques[1], Fernando Madureira[1], Volnei Tita[1, 2]

denys.marques@usp.br, fmadureira@usp.br, voltita@sc.usp.br

[1]*University of São Paulo, São Carlos School of Engineering, Department of Aeronautical Engineering., São Carlos, São Paulo, Brasil*

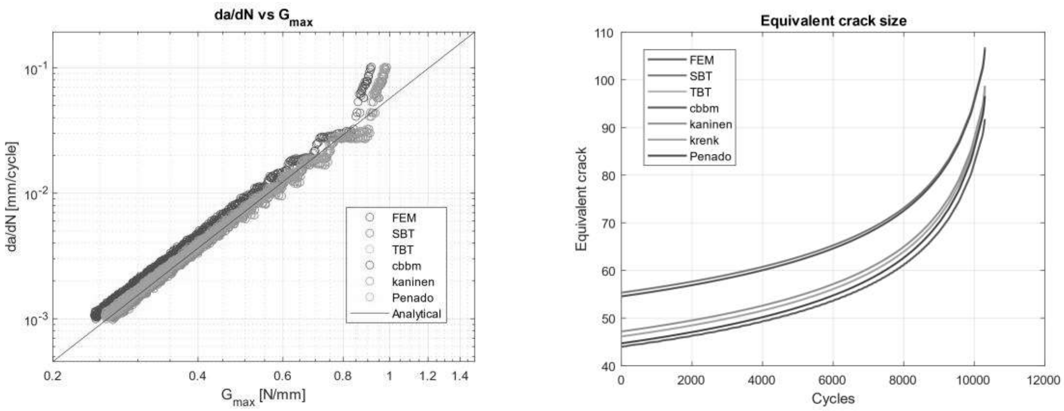
[2]*University of Porto, Faculty of Engineering of the University of Porto. Porto, Portugal.*

Throughout the years, different solutions have been proposed to evaluate the compliance, C, of adhesively bonded Double Cantilever Beam (DCB) as a function of the crack size present in the structure. This is important because, from the derivative of compliance, one can obtain the Strain Energy Release Rate in the structure (for Mode I opening) according to the Irwin-Kies equation (1):

$$G = \frac{P^2}{2b}\frac{dC}{da} \quad (1)$$

where P is the applied load, b is the width of the DCB, and a is the crack size. Furthermore, when performing fatigue tests on the DCB, it is more convenient to measure the compliance values and from that use a reduction scheme to obtain an equivalent crack size, i.e, $a=f(C)$, rather than measuring the actual crack size during the tests.

In the present work, we evaluate the performance of several reduction schemes in obtaining the Paris law parameters for an adhesive based on the compliance values obtained from a finite element analysis. For the numerical analysis, the delamination model proposed by Kawashita and Hallett [1] is implemented in Abaqus. According to the authors, the model applies to delamination propagation within the Paris-law regime and is suitable for the analysis of three-dimensional structures. The numerical model was used because it makes it possible to know *a priori* the Paris-law curve of the adhesive since it is an input of the model.



(a) (b)

Figure 1 – (a) Rate of crack propagation curve; (b) equivalent crack size obtained using different data reduction schemes.

The results show that all models evaluated can correctly predict the Paris curve of the adhesive (Figure 1), although the equivalent crack size may vary considerably between the different models.

Next, the different compliance models were evaluated regarding their ability to predict the fatigue life of an adhesively bonded DCB from a known Paris-law. The results are shown in Figure 2, and it is possible to see that the Simple Beam Theory (SBT) and Timoshenko Beam Theory (TBT) give unconservative predictions for the fatigue life of the bonded joint.

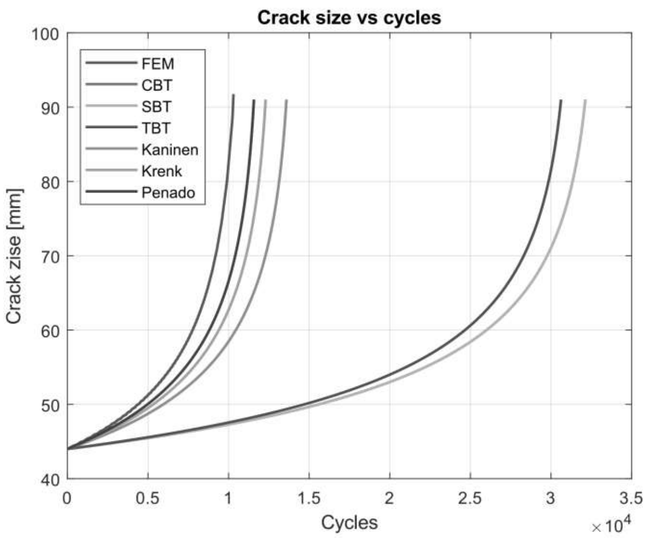


Figure 2 – Crack size versus cycles for different compliance methods.

REFERENCES

1. L. F. Kawashita, S. R. Hallett, A crack tip tracking algorithm for cohesive interface element analysis of fatigue delamination propagation in composite materials, International Journal of Solids and Structures, (2012), 2898-2913.