A Frequency-domain Approach for Fatigue Crack Propagation in Adhesively Bonded Joints

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In the present work, the phenomenon of crack propagation under random loads is investigated using Linear Elastic Fracture Mechanics and the Probability Density Function (PDF) of the loads calculated with the Narrowband method [1]. The method is applied to predict the fatigue life of a bonded joint under spectrum loads. The geometry used in this work is that of a skin made of glare with an aluminum stringer, as illustrated in Figure 1. This geometry was used by Freitas and Sinke to study the adhesive performance in stiffener-pull-of-tests [2].

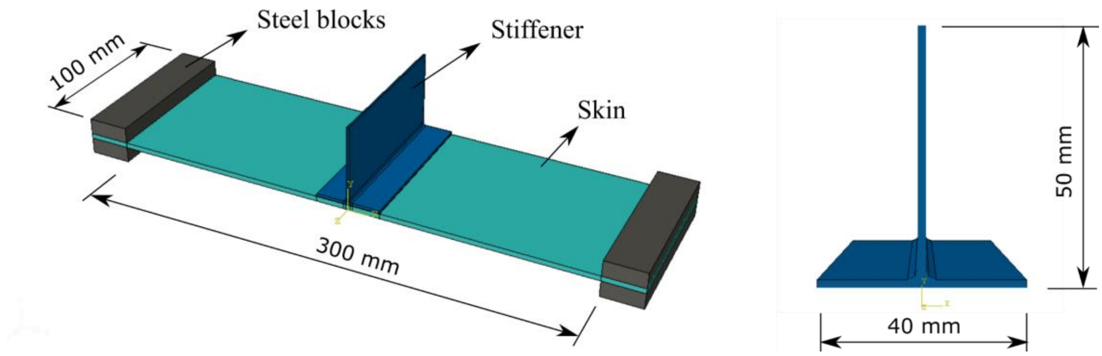

Figure 1 – Geometry used in this study.

The effect of damping in the response of the structure, as well as its impact in the fatigue life, was investigated by the introduction of modal damping in the numerical simulations of the response of the structure to a spectrum load applied at the top corner of the stiffener. Figure 2 illustrates how different damping values affect both the amplitude of the Frequency Response Function (FRF) of the structure as well as the PDF of the load response.

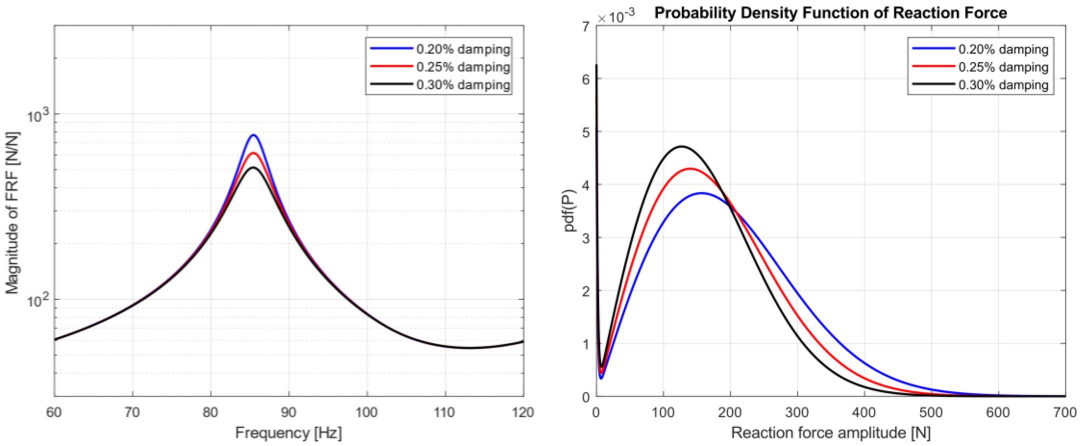

Figure 2 – Frequency Response Function of the reaction force (left) and Probability Density Function of the applied loads (right).

From the PDF of the load response, an equivalent, constant amplitude load may be found, which is then used in the calculations for the fatigue life of the structure. The adhesive was assumed to follow a Paris law in the form of

$$\frac{da}{dN} = CG^m\#(1)$$

where da/dN is the rate of crack propagation and G is the maximum strain energy release rate. In this work, the values of the Paris law' parameters were assumed to be $C = 0.057$ and $m = 3.0$. The values for the fatigue life of the structure are shown in Table 1.

Table 1 – Effect of damping on the fatigue life of the bonded joint.

Damping	**2.0%**	**2.5%**	**3.0%**
Fatigue life	24,574	48,933	86,145

The numerical results show the strong influence of damping on the structure's response and its effect on the fatigue life, in which an increase in the modal damping of the structure also leads to an increase in its life. This happens due to the dissipation effect caused by damping, which decreases the stress level in the adhesive layer.

REFERENCES

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2. S. T. Freitas, J. Sinke, Failure analysis of adhesively-bonded skin-to-stiffener joints: metal-metal vs. composite-metal", Engineering Failure Analysis, (2017), vol. 56, pp. 2-13.