doi:10.20396/revpibic262018366

Analysis of micro-defects in bonding of composites in metallic structures.

Éderson B. Martins Júnior*, Lucas S. Moura, Paulo Sollero

Abstract
Validation of a non-destructive procedure used in high-performance industries for micro-defects detection inside a composite repair, with a Finite Element Method (FEM) simulation using a cohesive law. For an experimental approach, a 3D vibrometer is used to scan the composite repair and detect possible debondings. Numerical results present good agreement with the performed experiments.

Key words:
Micro-defects, Composite, Debonding.

Introduction

Composite reinforcements are used for a wide range of repairs to metallic aircraft components, such as to reduce stress intensity in regions with cracks, or to increase static strength.[1] Repairing and inspecting micro-defects on these components demand the least possible intrusion and contact through any process.
Using an optical/laser instrument, a PSV-400 3D vibrometer, and an MTS fatigue testing machine, it is possible to detect a micro-defect in a composite repair. A FEM software was used to evaluate strain and stress fields on the repaired configuration.
The reliability in the experimental detection of micro-defects using a non-destructive method can be validated comparing its results with the numerical ones. This enhances the applications of these procedures on high-performance industries, improving the efficiency of crack detection and reducing the risks to damage the component under inspection, which would decrease its life service.

Results and Discussion

Plates made of aluminum 2024-T3 with a central crack repaired by a composite patch were used on the experimental model. For scanning the plates, the vibrometer uses three laser heads to measure the instantaneous vibratory displacements.[2] Thereby, the vibrometer could detect a debonding which occurred on the repair. Another vibration provided the lamb waves needed by the scanning equipment to detect it.
For the numerical model, *ANSYS Workbench®* was utilized. A Cohesive Zone Model (CZM), which has been successfully used to model fracture for a wide class of materials[3], was used. It takes advantage of damage laws to simulate the behavior of the adhesive, and eventually debonding in the composite reinforcement .[4]

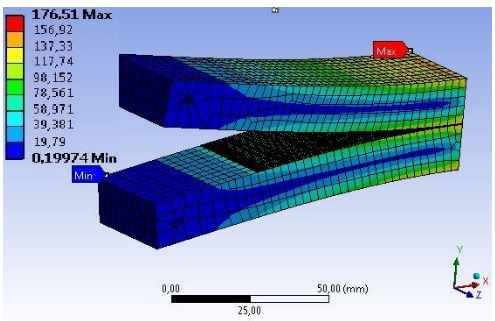

Figure 1. Debonding for mode I loading.

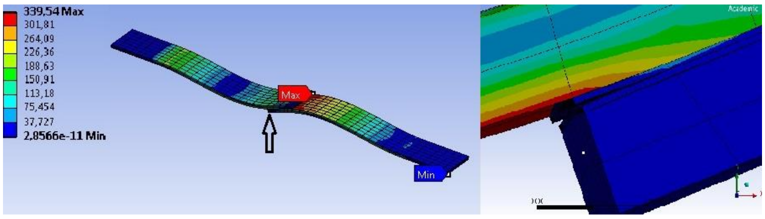

Figure 2. Debonding for mode II loading.

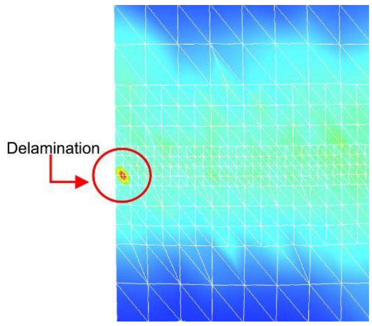

Figure 3. Composite repair under an optical/laser inspection.

For the numerical and experimental models, the tests showed good approximation. It was possible to validate the confidence between both approaches.

Conclusions

It was observed from the numerical model, a debonding as expected for each studied geometry.
For the experimental model, the vibrometer scanning provided the expected results, and it was observed that with a composite repair on the plate, the crack propagation was much slower. Therefore, the component has a life considerably longer under cyclic loading.

Acknowledgement

CNPq/PIBITI.

[1] Baker A.A.; Composite Structures 47 (1999) 431-443.
[2] Cazzolato, B.; Wildy, S; Condrington, J; Kotousov, A; and Schuessler, M. Polytec GmbH, Polytec-Platz 1-7, 76337 Waldbronn, Germany.
[3] J.C.S. Azevedo, R.D.S.G. Campilho, F.J.G. da Silva, T.M.S. Faneco and R.M. Lopes. Departamento de Engenharia Mecânica, Instituto Superior de Engenharia do Porto, Instituto Politécnico do Porto. **2015**, 80, 143-154.
[4] M, Alfano.; F, Furgiuele.; A. Leonardi .; C. Maletta.; and G. H. Paulino. Springer Science+Business Media B.V. **2008**, 157, 193-204.