Internship offer

Location : ISAE SUPAERO, Toulouse, France

Department : DMSM

Research group : Institut Clément Ader (ICA) transversal axis "Joining" [MS2M and MSC]

Supervisor : Éric PAROISSIEN, Frédéric LACHAUD

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OFFER DESCRIPTION

Title: **Assessment of adherence under fatigue loading by experimental and numerical testing.**

Proposed duration and period: 6 months on 2025 S1

Context

Aircraft structures are designed by the assembly of beams with concentrated caps and of thin plates, from initial design up to the maintenance (repairs). The objective is to set the material where it is needed to maximize the strength-to-mass ratio. The aircraft structural components are mainly assembled thanks joining technologies related to bolting. If bolting joining technologies are well controlled, its main drawback is the local reduction of the strength-to-mass ratio. Indeed, to reduce the local stress level to be transferred, the joining areas are mainly characterized by an increase of the thickness of materials to be assembled. On the contrary, it is acknowledged that the adhesive bonding technology allow for the increase of static and fatigue strength while reducing the mass. As a result, in the frame of the cost reduction, a solution for the design of aircraft structures could have built them by laying up adhesively bonded material sheets, to locally set the material where it is needed while avoiding over thicknesses.

The adhesive layer allows for the transfer of loads between the structural parts. To ensure this function, the adhesive layer must provide both cohesion and adhesion strengths. The topic of this internship is focused on the adhesion strength, called adherence.

Various experimental tests can be used to assess the adherence [1-4]. Among the existing tests, the three-point bending tests (3PBT), see Figure 1, allows for the localization of failure initiation as well as for the assessment of adherence at macroscopic scale [1]. Recently Birro et al. [5-8] suggest a methodology to assess the adherence under static loading, based on the coupling of experimental test and numerical test results at mesoscale involving Finite Fracture Mechanics (FFM) [9] and macro-element (ME) modelling [10-11].

This internship offer is included within a collaborative research project called AMETIST founded by the ANR (Agence Nationale de la Recherche) and is contributing in the TACCOS (Toulouse Adhesion Cohesion Collage Structural) initiative.

Objectives and work

The assessment of adherence under fatigue loading has not been yet investigated in the scientific literature. The objective of this internship is to assess the adherence of epoxy-to-aluminum interface under fatigue loading based on the 3PBT.

The expected work includes:

- literature review
- experimental testing using a dedicated test jig available at the lab: development of the experimental protocol (including instrumentation), test result analysis and post-mortem analysis of specimen
- numerical testing using analytical, ME modelling and FE modelling: simulation of tests (including the adaptation of a fatigue algorithm) and adherence assessment ability.
- report and presentation

This internship could lead to the submission of a scientific paper.

References	*[1] Roche, A.A., Behme, A., Solomon, J., 1982. A three-point flexure test configuration for improved sensitivity to metal/adhesive interfacial phenomena. International Journal of Adhesion and Adhesives, 2, 249-254.* https://doi.org/10.1016/0143-7496(82)90032-X *[2] Roche, A.A., Dole, P., Bouzziri, M., 1994. Measurement of the practical adhesion of paint coatings to metallic sheets by the pull-off and three-point flexure tests. Journal of Adhesion Science and Technology, 8(6), 587-609.* https://doi.org/10.1163/156856194X00366 *[3] Roche, A.A., Aufray, M., Bouchet, J., 2006. The role of the residual stresses of the epoxy-aluminum interphase on the interfacial fracture toughness. The Journal of Adhesion, 82, 861-880.* https://doi.org/10.1080/00218460600875771 *[4] Aufray, M., Roche, A.A., 2005. Properties of the interphase epoxy-amine/metal: Influences from the nature of the amine and the metal. In the book: Adhesion – Current Research and Application, Ed. POSSART W., WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim (DEU), ISBN: 9783527312634, Chap. 7, 89-101.* https://doi.org/10.1002/3527607307.ch7 *[5] Birro, T., Paroissien, E., Aufray, M., Lachaud, F., 2020. A methodology based on the coupled criterion for the assessment of adhesive-to-adherend interface crack initiation. International Journal of Adhesion and Adhesives, 102, 102664.* https://doi.org/10.1016/j.ijadhadh.2020.102664 *[6] Birro, T., Aufray, M., Paroissien, E., Lachaud, F., 2021. Assessment of interface failure behaviour for brittle adhesive using the three-point bending test. International Journal of Adhesion and Adhesives, 102, 102891.* https://doi.org/10.1016/j.ijadhadh.2021.102891 *[7] Birro, T., Paroissien, E., Lachaud, F., Aufray, M., 2022. On the effect of roughness parameters on adherence using the three-point bending test (ISO14679:1997). The Journal of Adhesion, 99(3), 492–517.* https://doi.org/10.1080/00218464.2021.2024808 *[8] Birro, T., Paroissien, E., Aufray, M., Lachaud, F., 2024. Analytical solution for the interfacial stress and energy release rate at failure initiation of the three-point bending test (ISO 14679:1997). Journal of Adhesion Science and Technology, 1-44.* https://doi.org/10.1080/01694243.2024.2359264 *[9] Leguillon, D., 2002. Strength or toughness? A criterion for crack onset at a notch. European Journal of Mechanics A-Solid, 21, 61-72.* https://doi.org/10.1016/S0997-7538(01)01184-6 *[10] Paroissien, E., Lachaud, F., Schwartz, S., 2022. Modelling load transfer in single-lap adhesively bonded and hybrid (bolted / bonded) joints. Progress in Aerospace Sciences, 130, 100811.* https://doi.org/10.1016/j.paerosci.2022.100811 *[11] Schwartz, S., Paroissien, E., Lachaud, F., 2024. An enriched finite element for the simplified stress analysis of an entire bonded overlap : continuum macro-element. International Journal of Adhesion and Adhesives, 129, 103571.* https://doi.org/10.1016/j.ijadhadh.2023.103571

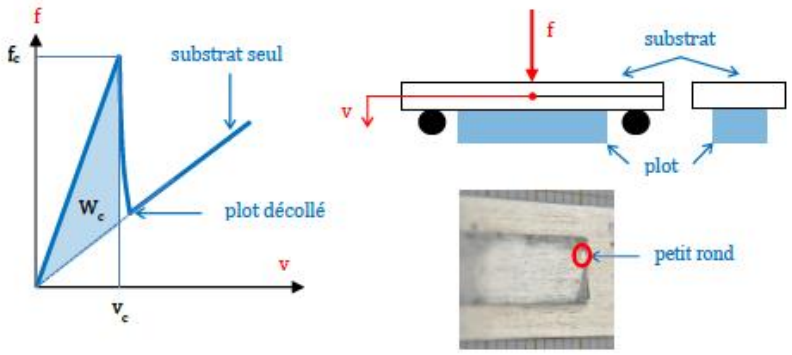

Figure 1 – Three-point bending test.

Possibility to continue with a PhD (Yes/No) : TBD

REQUIRED APPLICANT PROFILE AND SKILLS

Study level	☐ Undergraduate students (3rd or 4th year) ■ Master students (1st or 2nd year) ☐ PhD students
Required profile and skills	This offer is suitable to students in last year of MSc, MEng in Solids Mechanics, Structures Mechanics. The expected specific skills are : • fundamentals of strength of materials • basics on the FE method
Other useful information	Feel free to take contact Gratification (around 550 € per month depending on worked days)