Research project offer

Location : ISAE SUPAERO, Toulouse, France **Department** : DMSM **Research group** : "Joining" transversal axis [MS2M and MSC] **Supervisor** : Éric PAROISSIEN, Michel SALAÜN, Sébastien SCHWARTZ **Email** : eric.paroissien@isae-supaero.fr, frederic.lachaud@isae-supaero.fr, sebastien.schwartz@isae-supaero.fr	
OFFER DESCRIPTION	
Title : Simplified stress analysis of adhesively bonded joints based on elastic continuum plane media approaches **Proposed duration and period** : 6 months, S2 2022	
Context	Aircraft structures are designed by the assembly of beams with concentrated caps and of thin plates. 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 be built them by laying up adhesively bonded material sheets, in order to locally set the material where it is needed while avoiding over thicknesses. The Finite Element (FE) method is able to address the stress analysis of multilayered structures. Nevertheless, since analyses based on FE models are computationally costly, it would be profitable both to restrict them to refined analyses and to develop for designers simplified approaches, enabling extensive parametric studies. As highlighted in several literature surveys [1-3], a large number of simplified approaches for the stress analysis of bonded joints exist in literature. One of promising techniques is the macro-element technique, the efficiency of which has been demonstrated in the case of two bonded beams (see Figure 1). The macro-element technique method, originally presented in [4,5], is inspired by the FE method and allows for the resolution of the set of governing differential equations. The displacements and forces in the adherends, as well as the adhesive stresses, are then computed. The method consists in meshing the structure. A fully bonded overlap is meshed using a unique 4-node macro-element, which is specially formulated. This macro-element is called bonded-bar (BBa) or bonded-beam (BBe). According to the classical FE rules, the stiffness matrix of the entire structure – termed K – is assembled and the selected boundary conditions are applied. The minimization of the total potential energy leads to find the vector of nodal displacements U such that F=KU, where F is the vector of nodal forces. This approach based on macro-elements takes advantage of the flexibility of FE method. Indeed, by employing a macro-element as an elementary brick, it offers the possibility to simulate complex structures involving single-lap bonded joints at low computational costs [6]. The current method makes use of simplifying hypotheses of classical models, such as Volkersen, Goland and Reissner or Hart-Smith [7-11], describing the joint as two beams of one or two parameter elastic foundation. In particular, the ME modelling is able to provide solutions where the closed-form ready-to-use solutions of classical simplified stress analyses based on elastic foundation cannot be applied.
Objectives and work	The simplified stress analyses based on elastic foundation does not allow the respect of free traction surface conditions at both overlap ends, due to the hypotheses made on the adhesive stress tensor.

The objective of the present Research project is to assess the ability of the formulation of ME based on simplified stress analyses based on elastic contiunuum plane media approaches.

Two relevant recent papers [15-16] already selected will drive the works, which shall include:

- bibliographic review on the stress analysis of bonded joining of materials and structures in order to appropriate the topic
- understanding and appropriation of both driven papers
- numerical implementation of both models
- development of dedicated methodologies for the ME stiffness matrix
- implementation and validation.

References

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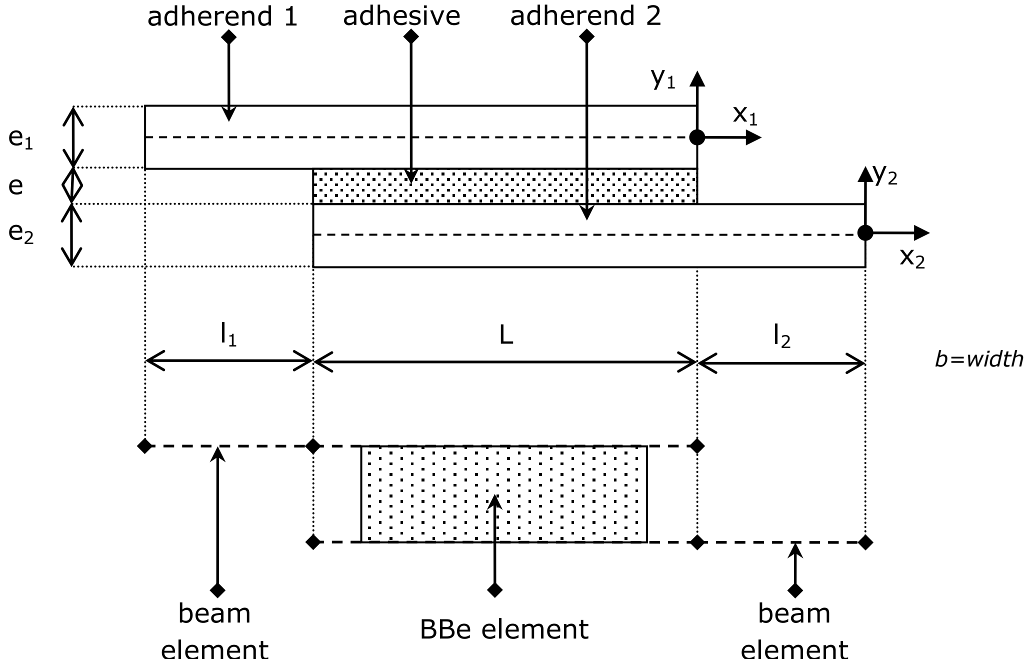

Figure 1 – Modeling with macro-element technique.

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

REQUIRED APPLICANT PROFILE AND SKILLS	
Study level (tick possible choices)	☐ 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