



## Post-doctoral position

Laboratoire Brestois de Mécanique et des  
Systèmes  
ENSTA Bretagne - Brest



### Characterization of the fracture toughness of hybrid bonded joints for marine renewable energy applications

#### Contact

##### Nicolas Carrere

Industrial chair « Long term strength of adhesively hybrid bonded assemblies in a marine environment. Application to renewable marine energy systems »

Laboratoire Brestois de Mécanique et des Systèmes (ENSTA-Bretagne / UBO / ENIB)

ENSTA-Bretagne, 2 rue François Verny, 29806 Brest Cedex 9

E-mail : [nicolas.carrere@ensta-bretagne.fr](mailto:nicolas.carrere@ensta-bretagne.fr)

Tel : +33(0)2 98 34 88 67

#### Context

A post-doctoral fellowship is available at LBMS-ENSTA Bretagne ([www.lbms.fr](http://www.lbms.fr)) in the field of the characterization of hybrid bonded joints for marine renewable energy applications (off-shore wind turbines, tidal turbines...). The present fellowship is partly funded in the framework of an industrial chair « Long term strength of adhesively hybrid bonded assemblies in a marine environment: Application to renewable marine energy systems ». This fellowship is a part of a project developed at the LBMS (N. Carrere & J. Y. Cognard) in collaboration with IFREMER (P. Davies, Brest) and with Sika (P. Jousset, Sika Technology AG, Zurich, Switzerland) on the assessment of long term behavior of bonded joints for wind turbine applications.

#### Project

The use of renewable energy is a major issue both from an environmental and an economic point of view. A key point for the development of renewable energy lies in the use of larger turbine blades in order to increase the performance. This is the reason why wind turbine blades are manufactured using composite materials in order to decrease the weight and are made of several pieces. The assembly of these composite parts (but also of composite and metal parts) is thus of major importance, and may determine the in-service durability. The aim of this post-doctoral position concerns the assessment of bonded assemblies subjected to cyclic loads. This work can be divided into three main aspects: (i) characterization of the toughness of bonded joints subjected to complex loadings (for instance shear and out-of-plane loadings, the characterization under mixed mode can be seen as an open problem), (ii) a possible extension of these tests for the characterization of the fatigue crack propagation and (iii) the development of a methodology based on cohesive zone models to describe the propagation of cracks in a Finite Element code.

The characterization of the fatigue crack growth will be performed using classical fracture mechanics tests. The DCB test will be used to characterize the fatigue crack growth in mode I and MMB tests for other mixed mode ratios. In a first step, the crack propagation under monotonic loading will be assessed. A complete description of the evolution of the toughness as a function of the mixed mode ratio will be performed. In a second time, it can be studied the possibility of extending these tests to determine the fatigue crack growth behaviour.

In order to characterize the toughness of the bond under complex loadings (mixed modes), a

test based on the modified Arcan test device will be developed. Classically, the Arcan test is used to characterize the strength of bonded joints under various loadings (tension, pure shear, tension and shear, compression and shear). The aim is here to use this kind of test to characterize the crack propagation. In order to attain this goal, the experimental procedure (especially the shape of the specimens, the metrology and the method of analysis to assess the toughness) will be developed. First, a comparison with classical fracture mechanics will be performed to validate the proposed methodology. In a second step, the determination of the toughness under combined tensile/compression and shear loading will be performed.

Finally a cohesive zone model will be proposed to describe the failure of bonded structures. Cohesive zone models are based on two aspects: (i) a criterion to describe the onset of the damage and (ii) a criterion to describe the propagation. Many models of cohesive zone are proposed in the literature, but most of them have been written specifically for the delamination of composite laminates. In the present study, the onset criterion will be determined thanks to Arcan tests (performed during a PhD associated to the project) and the propagation criterion will have been determined using the fracture mechanics tests or the propagation tests using Arcan tests performed during the Post-Doctorate.

**Duration**

18 months

**Salary**

Around 2000€ per month

**Qualifications**

- PhD thesis in mechanical engineering
- Finite element modelling
- Experimental techniques
- Fracture mechanics (not essential)

Candidates must have spent at least six months out of France during the last 12 months

**Application**

An application letter, a CV and a small description of the previous research must be sent by e-mail to [nicolas.carrere@ensta-bretagne.fr](mailto:nicolas.carrere@ensta-bretagne.fr).

Administrative contact: Jean Pierre BAUDU, Secrétaire Général, ENSTA Bretagne, [jean-pierre.baudu@ensta-bretagne.fr](mailto:jean-pierre.baudu@ensta-bretagne.fr).