8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

A NON ASSOCIATED ELASTO-VISCO-PLASTIC MODEL SUITED TO THE NUMERICAL SIMULATION OF 2D ADHESIVELY BONDED ASSEMBLIES WITH INTERFACE ELEMENTS

***R. Créac'hcadec[1], J.Y. Cognard[1] and L. Sohier[2]**

[1] Mechanics of Naval and Offshore Structures, ENSIETA
2 rue F. Verny
29806 Brest Cedex 09, France
Romain.Creachcadec@ensieta.fr
Jean-Yves.Cognard@ensieta.fr

[2] Laboratoire d'Ingénierie Mécanique et Electrique, UBO
29285 Brest, France
Laurent.Sohier@univ-brest.fr

Key Words: *Interface Elements, Non-Associated Plasticity, Viscoelasticity, Inverse Identification Technique, Adhesive Modeling.*

ABSTRACT

The final objective of this work is to define a reliable tool for dimensioning of adhesively bonded assemblies, particularly for marine and underwater applications.

In a previous study, an experimental methodology enabling the adhesives of interest to be characterized up to failure has been proposed [1]. A modified Arcan fixture, which allows compression or tension to be combined with shear loads, has been designed. It has been numerically shown, on one hand, that the use of a beak close to the adhesive joint makes it possible to limit the contribution of the singularities due to edge effects; and on the other hand, that the geometry of the joint near the edge is an important parameter. This experimental fixture associated with non-contact extensometry and optimization techniques allows us to analyze, for proportional loadings, the non linear behaviour of an adhesive joint (epoxy resin Huntsman™ Araldite® 420 A/B has been used). The experimental data are defined by curves relating the relative displacement of both ends of the adhesives versus the applied load.

The next step of the work detailed in this paper is the development of a model in order to represent the non linear behaviour of the adhesive joint. The aim is to propose a numerical tool for 2D adhesively bonded assemblies which allows us to take into account the non linear behaviour of the adhesive with a low numerical cost. When the dimension of one of the constituent of an heterogeneous structure is small with respect to the others, it is possible to replace the continuum elements by an interface element or a joint element [2]. These elements use the same type of nodal variables as continuum finite elements and therefore they can be easily combined. However, while for continuum elements the relevant variables at the integration points are the components of the local stress tensor, the relevant quantities for the joint element are the components of the local stress vector acting on the interface. Thus we have to propose a model which represents the evolution of the relative displacement of both extremities of the adhesive joint as a function of the stress state.

To describe the behaviour of the adhesive under proportional loadings for a given strain rate, a 2D non-associated elasto-plastic behaviour law has been proposed in order to represent accurately the experimental data. The elastic yield surface is defined as a dissymmetric elliptic function. The flow rule is described by a second elliptic function. The interest of this model is to reach the important ratio, around 20, between the relative displacements in the normal and tangential directions of the adhesive observed experimentally for traction–shear loads. The model has been implemented in the finite element code CAST3M using a return-mapping algorithm [3]. Besides it is also necessary to take into account the various viscous phenomena of the adhesive behaviour [1] which are quite important for the adhesive used. Thus an extension of this model is proposed in order to take into account some aspects of the viscous phenomena.

Moreover, numerical simulations performed assuming linear-elastic material behaviour of the constituents showed a non-uniform stress evolution in the adhesive for the Arcan test [1]. Thus inverse techniques have been developed to characterize the parameters of the adhesive behaviour. A coupling method between the optimization software MATLAB and the finite element code CAST3M is used to perform the identification of the of the non-associated elasto-visco-plastic law behaviour, starting from a large experimental data base (load-displacement curves). The proposed model represents accurately the different experimental responses for proportional traction/compression–shear loadings and for a large range of deformation rate.

Numerical results for adhesively bonded assemblies will be presented. The proposed strategy allow us to take into account the non linear behaviour of the adhesive with a low numerical cost in order to optimize the design of adhesively bonded structures.

REFERENCES

[1] J.Y. Cognard, P. Davies, L. Sohier, R. Créac'hcadec, "A study of the non-linear behaviour of adhesively-bonded composite assemblies", *Composites Structures*, Vol **76**, pp 34-46, (2006).

[2] P. Pegon, A.V. Pinto and M. Géradin, "Numerical modelling of stone-block monumental structures", *Computers & Structures*, Vol. **79**, pp 2165-2181, (2001).

[3] V. Magnier, E. Charkaluk, C. Bouby and G. De Saxcé, "Bipotential versus return mapping algorithms: implementation of non-associated flow rules", *Eighth International Conference on Computational Structures Technology*, paper **68**, ©Civil-Comp Press, (2006).