Modelling and identification of a nonlinear finite element connector for the simulation of bolted assemblies

P.-A. Guidault†,*, M.-F. Soulé de Lafont† and P.-A. Boucard†

† LMT, ENS Cachan, CNRS, Université Paris-Saclay
61 avenue du Président Wilson, 94235 Cachan Cedex, France
Email: {guidault,souledelafont,boucard}@ens-paris-saclay.fr
- Web page: http://www.lmt.ens-cachan.fr

ABSTRACT

Bolted joints are widely encountered in mechanical engineering, especially in aeronautics (e.g. 3,000,000 joints on a A380, 50,000 on a Rafale). In spite of well-established design rules and assembly procedures, important sources of uncertainty remain due to a high sensitivity of the joint mechanical behaviour to dispersions (tightening procedure, frictional effects, geometrical tolerances...).

Fine scale computations of bolted assemblies accounting for these uncertainties are generally too costly and hardly tractable within an optimization process. Thus, a wide range of FE connectors or user-elements are usually used or developed in FE commercial code by engineers to propose a simplified model for bolts. The connector behaviour is generally identified from fine scale 3D computations on an elementary bolded joint and/or from experimental tests. However, identification is often limited to the elastic part of the behaviour and for a given set of loadings and design parameters. In specific situations, simplified analytical models exist [1] but they mainly address linear dynamic or quasistatic problems.

In this work, a nonlinear FE connector with its identification methodology is proposed to model the behaviour of a bolt joint [2,3]. Model parameters are based on design parameters (bolt prestress, friction coefficient, clearance, bolt dimensions…). Axial connector behaviour models the preload effect and the axial bolt stiffness [4]. Tangential connector behaviour accounts for frictional phenomena that occur in the bolt's vicinity due to preload thanks to an elasto-plastic analogy for friction [5]. Identification of tangential behaviour is performed on a generic elementary single bolt joint. Connector has been developed in SAMCEF through a fortran user-element subroutine. Comparisons between fine scale 3D computations and simulations with connectors on various bolted assemblies will be proposed. In particular, it will be shown that dissipated energies are in good agreement.

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