11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

# CONTACT CONSTITUTIVE LAWS FOR FIBER-REINFORCED COMPOSITE MATERIALS

**Luis Rodríguez-Tembleque**

Escuela Técnica Superior de Ingeniería, Universidad de Sevilla, Camino de los Descubrimientos s/n , Sevilla E-41092, Spain, luisroteso@us.es

**Key words:** *Composite Materials, Fiber Reinforced Plastics, Micromechanics, Anisotropic Friction, Anisotropic Wear, Contact Mechanics*

Fiber-reinforced polymer (FRP) composites are highly demanded for numerous applications in aerospace, automotive or biomedical industries, due to their high values of specific strength and stiffness, or excellent biocompatibility. Although the FRP are widely applied in many structures and mechanical components that are subjected to different frictional contact conditions, the numerical characterization of their tribological response has not been fully completed. In the literature, some experimental works [1, 2, 3, 4] have studied the significant influence of fiber orientation on the wear and frictional behavior of FRP composites. Contact problems where FRP are involved, require more complex contact laws were micromechanical aspects have to be considered (i.e. fiber orientation relative to the sliding direction or fiber volume fraction).

This work presents contact constitutive laws for friction and wear modeling in fiber-reinforced plastics. These laws are incorporated to a numerical methodology which allow to solve the contact problem taking into account the anisotropic tribological properties on the interfaces. This formulation uses the Boundary Element Method (BEM) and/or the Finite Element Method (FEM) for computing the elastic influence coefficients, and contact operators over the augmented Lagrangian to enforce contact constraints. An anisotropic wear model is considered, together with an orthotropic friction law [5, 6, 7]. Furthermore, the formulation considers a micromechanical model for FRP that allows also taking into account the fiber volume fraction or fiber characteristics.

The proposed contact laws and the numerical methodology are applied to study some FRP materials. In these studies, it can be observed how the fiber orientation, fiber volume fraction, or sliding orientation affect the normal and tangential contact compliance, as well as the contact traction distribution and wear evolution.

## REFERENCES

[1] N. Ohmae, K. Kobayashi and T. Tsukizoe. Characteristics of fretting of carbon fibre reinforced plastics. *Wear*, Vol. **29**, 345–353, 1974.

[2] N.H. Sung and N.P. Suh. Effect of fiber orientation on friction and wear of fiber reinforced polymeric composites. *Wear*, Vol. **53**, 129–141, 1979.

[3] T. Tsukizoe and N. Ohmae. Friction and wear of advanced composite materials. *Fibre Sci. Technol.*, Vol. **18**, 265–286, 1983.

[4] T. Larsen, T.L. Andersen, B. Thorning, A. Horsewell and M. Vigild. Fretting wear performance of glass-, carbon-, and aramid-fibre/epoxy and peek composites. *Wear*, Vol. **262**, 1013–1020, 2007.

[5] L. Rodríguez-Tembleque, R. Abascal, M.H. Aliabadi. Anisotropic wear framework for 3D contact and rolling problems. *Comput. Meth. Appl. Mech. Eng.*, Vol. **241**, 1–19, 2012.

[6] L. Rodríguez-Tembleque, R. Abascal. Fast FE-BEM algorithms for orthotropic frictional contact. *Int. J. Numer. Methods Eng.*, Vol. **94**, 687–707, 2013.

[7] L. Rodríguez-Tembleque, F.C. Buroni, R. Abascal and A. Sez. Analysis of FRP composites under frictional contact conditions. *Int. J. Solids Struct.*, Vol. **50**, 3947–3959, 2013.