



## Post-doctoral position (12 months since sept. 2020)

### “Improvement in modeling contact and friction within steel wire ropes”

#### Scientific context

Steel wire ropes are largely used in many applications like suspension bridges, elevators, or mooring lines for the station keeping of offshore engineering structures. IFP Energies nouvelles (IFPEN) is concerned with the latter case for the development of floating offshore wind turbines technologies. As the other structure components, the wire rope should be designed to resist wind, wave, and turbine solicitations during the structure life, avoiding ultimate and fatigue failures. The fatigue of wire rope is particularly difficult to estimate, in particular with bending, as it involves relative sliding with friction of the different wire layers inside the rope. This explains why a large number of failures have been experienced in oil and gas industry which have not been predicted by the empirical rules recommended by the international standards, in particular near socket ends [Fontaine et al, 2014]. In this context, IFPEN has been developing a multi-scale approach linking the results of aero-hydro-elastic model of wind turbine to a detailed Finite Element model of the wire rope, and finally a fretting fatigue model at the wire scale.

This post-doctorate follows the doctoral thesis [Bussolati, 2019] which was supervised by the Laboratoire de Mécanique et Technologie (LMT) of ENS Paris-Saclay and IFPEN. During this thesis, a user element has been developed in Abaqus Finite Element software for the detailed Finite Element of a wire rope metric scale segment. This model considers contact and friction between non parallel beams, each wire of the wire rope being modelled by a beam model. It takes advantage of the small sliding assumption to avoid time consuming update of the contact pairing during the deformation. Results are comparable with those obtained with large sliding algorithms but with a significant CPU time reduction.

F. Bussolati., (2019). « Modèle multi-échelle de la fatigue des lignes d’ancrage câblées pour l’éolien offshore flottant ». Doctoral thesis of Université Paris-Saclay. <https://tel.archives-ouvertes.fr/tel-02307977>

E. Fontaine, A. Kilner, C. Carra, D. Washington, K. Ma, A. Phadke, D. Laskowski, and G. Kusinski (2014). “Industry survey of past failures, pre-emptive replacements and reported degradations for mooring systems of floating production units”. In Offshore Technology Conference.

#### Objectives

The first objective of this post-doctorate is to extend the current user model in Abaqus, in order to include the case of the contact between parallel beams/wires. This case can be encountered for adjacent layers of wires with similar lay angles in some ropes of large diameter designed for high tension. It will also improve the cable representation when intra-layer contacts between adjacent wires occur during bending.

The second objective is to migrate the current Abaqus model to the open source Code\_Aster software of EDF R&D (<https://www.code-aster.org>). This action is important to allow the use of this model in future development of optimized and reliable design methodologies which require a very large number of simulations.

Finally, the post-doctorate will work on improvement of the robustness and accuracy of the model. The current version uses a penalty regularization of the contact reaction vs displacement law which

leads to approximations in the radial location of the wires. Such approximations may lead to error in the force equilibrium within the wires and can be improved for instance by using Lagrangian multipliers.

The development will be made in collaboration with Dr. P.-A. Guidault from LMT at ENS Paris-Saclay. A demonstration of its interest will be provided by industrial applications.

### **Candidate profile**

The candidate should have defended a doctoral thesis in Solid Mechanics with Finite Element development involving non-linear transformation and if possible, contact and friction. Strong knowledge in programming (Python, Fortran) is expected. Experience with Code\_Aster or Abaqus will be appreciated.

### **Localization**

IFP Energies nouvelles-Direction Physico-chimie et Mécanique appliquées.

Lyon site, Rond-Point de l'échangeur de Solaize, BP 3, 69360 Solaize, France.

### **Application**

To apply, send to Dr. Martin Guiton at [martin.guiton@ifpen](mailto:martin.guiton@ifpen) with email title “Application to wire rope model post-doctorate”: a detailed CV, a list of publications, a covering letter with recommendations, and for already defended theses, the defense report.