Modeling multilayered wire strands, a strategy based on 3D finite element beam-to-beam contacts - Part I: Model formulation and validation

Sébastien Lalonde, Raynald Guilbault, Frédéric Légeron

www.elsevier.com/locate/ijmecsci

PII: S0020-7403(16)30591-4
DOI: http://dx.doi.org/10.1016/j.ijmecsci.2016.12.014
Reference: MS3526

To appear in: *International Journal of Mechanical Sciences*

Cite this article as: Sébastien Lalonde, Raynald Guilbault and Frédéric Légeron Modeling multilayered wire strands, a strategy based on 3D finite element beam to-beam contacts - Part I: Model formulation and validation, *International Journal of Mechanical Sciences* http://dx.doi.org/10.1016/j.ijmecsci.2016.12.014

Modeling multilayered wire strands, a strategy based on 3D finite element beam-to-beam contacts - Part I: Model formulation and validation

Sébastien Lalonde[a], Raynald Guilbault[b], Frédéric Légeron[c]

[a]Université de Sherbrooke, Faculty of Engineering, Department of Civil Engineering, Sherbrooke, Canada
[b]École de technologie supérieure, Department of Mechanical Engineering, Montreal, Canada
[c]Parsons Corporation, Abu Dhabi, United Arab Emirates

Abstract

This paper proposes a FE modeling strategy for multilayered strands subjected to multiaxial loads. The approach takes advantage of beam elements and incorporates 3D inter-wire contacts. While reducing mesh sizes, it handles any strand configuration. Comparisons with experimental results validate its precision. The analysis shows that friction forces control the hysteresis and the bending stiffness. The paper develops a multi-level friction coefficient better representing the stick and slip zones, and to account for indentation, the model incorporates a friction orthogonality concept; the axial direction is controlled by adhesion, while the orthogonal direction is associated with adhesion and deformation contributions.

Keywords: Multilayered wire strands, Finite element modeling, Bending loads, Inter-wire contact, Beam-to-beam contact, Frictional contact

1. Introduction

Multilayered helical strands are key components in many engineering structures, such as suspension and cable-stayed bridges, guyed towers, and power transmission lines. Mainly designed to support high axial static forces, strands are also subjected to dynamic transverse loads (such as wind-induced vibrations) generating free cyclic bending. Near restrained terminations, cyclic bending may induce critical fretting damage at inter-wire contact interfaces, consequently affecting cable service life [1,2]. Characterizing and understanding the mechanical behavior of helical strands under multiaxial loading is thus critical for the structural integrity assessment of engineering structures. This paper develops an efficient modeling strategy for multilayered strands submitted to combined axial and bending loads. Although not restricted to, the proposed modeling approach is oriented to the analysis of overhead conductors.

Due to contact interactions between wires, multilayered strands (Fig. 1a) exhibit a variable bending stiffness (EI); as the strand curvature (κ) increases, the wires progressively start to slip on each other, resulting in a significant reduction of the bending stiffness. Therefore, particularly as a result of the anti-symmetricity of the problem [3], formulating a mechanical model of helical strands submitted to multiaxial loads, including bending moments, represents a difficult task.