Wire rope model with elliptic cross sectional outer wires

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Abstract

Wire ropes are used in variety of application areas such as cranes, bridges, mining due to their large tensile and in addition easy storage capability. It is inevitable to carry out numerical tests in order to determine rope behaviors in different application fields. Three dimensional solid models without errors are needed for finite element analysis. Therefore, the three-dimensional meshed model must be prepared for analysis. Traditionally, wire ropes made by using circular cross-sectional wires but this behavior is started to change due to the different needs in various application areas. For this reason, it seems that different types of rope models have been designed, such as flattened or swaged rope surfaces. In this article, a mesh model of a wire rope with an elliptical cross-sectional outer wires has been created. This model has a great emphasis in the creation of rope models with using different cross-sectional outer wires. In future studies, other type of cross-sectional outer wires can be used to model new wire ropes using the similar technique.

Keywords: **Wire Strand, Wire Rope, Independent Wire Rope Core, meshed helical model**

Introduction

Love is described the mechanical theory of thin rods in his treaties named "Theory of Elasticity" [1]. In this book Love mentions the mechanical characteristics of thin rods and gives the general equilibrium equations. After 1970, with the help of computer technology, many studies are published in the literature. Costello's papers on various aspects of wire ropes are shed light to many other researchers to study the different behavior of wire ropes [2]. By using the Finite Element Analysis capability in engineering applications computer models of wire strands and wire ropes are take attention. At the beginning of the seventies, Carlson and Kasper built a simplified model for armored ropes using the finite element method [3]. A finite element model of a simple straight strand based on a Cartesian isoparametric formulation is given by Nawrocki who take into account every possible interwire motion in [4]. A wire rope with an IWRC model, which fully considers the double-helix configuration of individual wires considered by Elata et.al. in [5]. Parametric mathematical equations of single and double helical wires within an IWRC is represented in [6]. Modeling issues of nested helical structure based geometry for numerical analysis and the encountered problems and solution techniques are mentioned in [7]. Lately a geometric model of spiral one or two-layered oval nested wire strands are proposed by Stanova et.al. in [8].

Modeling wire rope structures needs a comprehensive care for Finite Element Analysis (FEA) due to the requirement of error free structured meshed model of the wire rope for FEA. Structure of a wire rope consists of different sized wires with various pitch lengths and helix angles. In addition wires within a wire strand or wire rope named according to its form as straight, single, double or triple. These types of helical shapes are composed by coiling a wire around another or wrapping a strand over another one. But before this wrapping process each wire basically has a cylindrical shape with circular cross sections. Wire ropes are seen in

different structures according to their usage areas. Some new kind of wire ropes by using non-common cross sectional shaped wires such as a strand created by using some techniques such as compacting, swaging, plastic coating and filling or using different shaped outer wires such as elliptic outer wires. The process of compacting or swaging flattens the surface of the outer wires and reforms internal wires of the strand to increase the density of the strand. In compacted wire rope represented in Figure (1) or swaged wire rope, the wires are compacted or reduced in diameter while stranding operation or in a separate operation after stranding. Due to need for mechanical process for compacting or swaging, elliptical outer wires are preferred to use in numerical modeling of wire ropes to find flattened outer surface. The importance of this modeling process is to have a meshed model of the wire rope at the same time without the need for any other tool. Once the necessary parameters such as pitch length, rotational angles, wire radiuses and the type of the wire rope are defined the meshed model of the wire rope is created at the same time which is ready to make FEA.

Each wire within a wire strand or wire rope are straight wires at the beginning of the wounding process. Wires within a wire strand consists of a straight center wire wound by 7 single helical wires called as Wire Strand (WS). Single helical wires also composed by using straight wires. Before wounding process each wire is commonly has a circular cross sections. In this article a strand, whose outer wire cross section is elliptic, is modeled and meshed. It has a straight center wire which is coiled up with six elliptic shaped outer wires as presented in Figure (2).

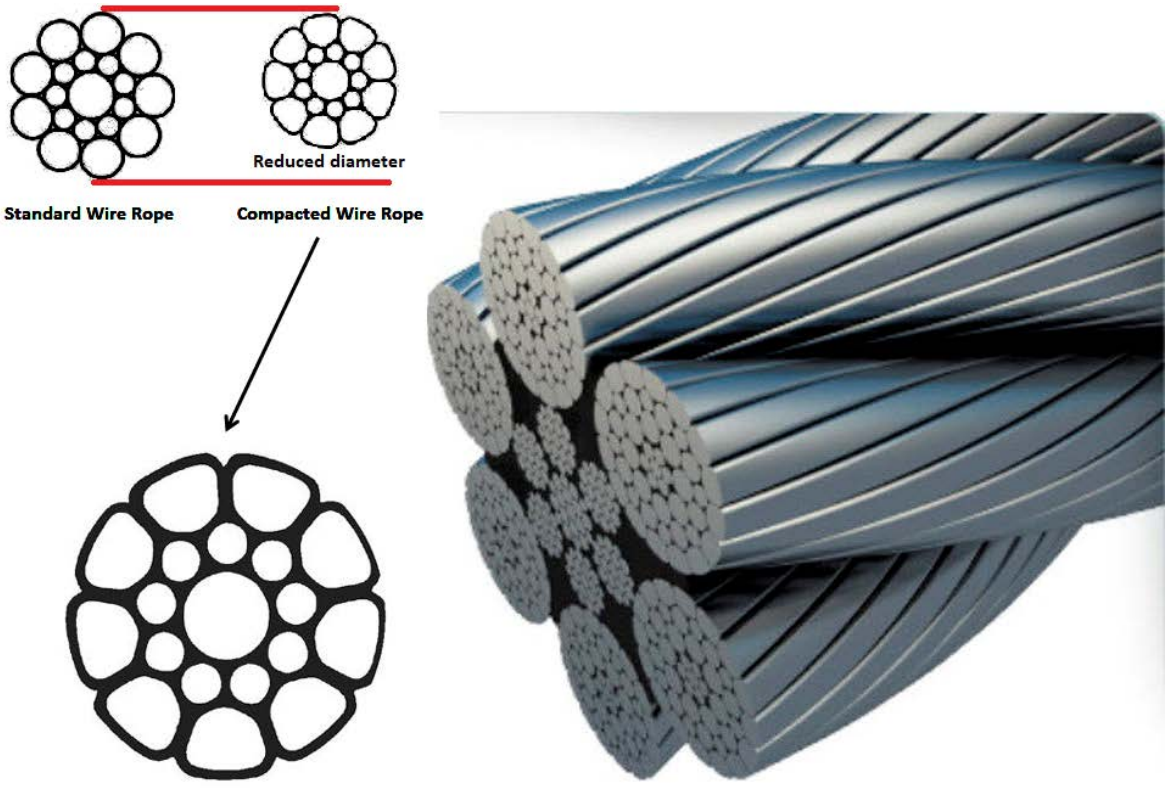

Figure 1: Compacted wire rope.

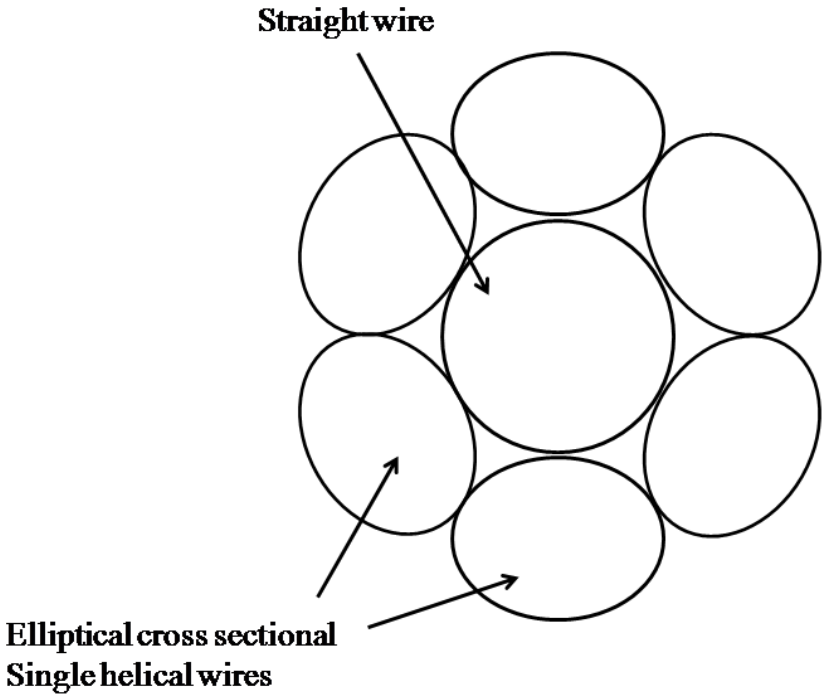

Figure 2: A simple wire strand with elliptic outer wires.

Conclusions

Wire rope modeling with different shaped cross-sectional outer wires is described in this paper. The meshed 3D model of the wire strand is modeled using the parametric equations of helical geometry. The importance of this modeling process is to have a meshed model of the wire rope at the same time without the need for any other tool. In this article a strand, whose outer wire cross section is elliptic, is modeled and meshed. It has a straight center wire which is coiled up with six elliptic shaped outer wires. This modeling issue enables to analyze various shaped wire ropes using the Finite Element Analysis. In addition other type of shapes could be modeled using the described modeling technique to create different type of wire ropes.

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