International Journal of Offshore and Polar Engineering
Vol. 3, No. 3, September 1993 (ISSN 1053-5381)

Cyclic Bending Characteristics of Sheathed Spiral Strands in Deep Water Applications

Mohammed Raoof and Yu Ping Huang
School of Architecture and Civil Engineering, South Bank University, London, United Kingdom

ABSTRACT

Straightforward design formulations are given for determining some nonlinear free-bending characteristics of axially preloaded and large-diameter sheathed spiral strands experiencing high external hydrostatic pressure in, for example, deep water floating platform applications. The proposed simple formulations provide means of estimating bounding solutions to strand plane-section bending stiffness, (EI)eff, and hysteresis plus associated critical imposed radii of curvature for any assumed level of external hydrostatic pressure. The practical limitations of the theoretical formulations are discussed in some detail in the light of recent experimental findings in related areas.

INTRODUCTION

Fairly recently, the cable manufacturers have offered high-density and supposedly impermeable polythene sheaths for corrosion protection of large-diameter spiral strands in very deep water applications. Under such conditions, the clench forces caused by the hydrostatic water pressure may become significant compared with the clench forces inside the cable caused by the mean axial load in, say, a guyed tower platform application.

Such external pressures on a sealed multilayered spiral strand will tend to suppress the relative slippage of wires in the cable by increasing the frictional forces between them. A higher strand axial (Raoof, 1989a) and torsional (Raoof, 1990a, 1990b) stiffness will then follow. Moreover, such external pressures may also lead to significant reductions in the axial and restrained bending fatigue life of sheathed spiral strands (Raoof, 1990, 1991a, 1991b, 1992d).

The basis of the free-bending theoretical model for both sheathed and unsheathed and axially preloaded spiral strands has already been reported in some detail elsewhere (Raoof and Huang, 1992a, 1992c) where related work by others has also been cited. As discussed by Raoof (1990a), due to the presence of significant frictional forces between the individual helical wires in a strand, for large enough radii of curvature, initiation of interwire slippage can be totally suppressed and the whole strand effectively behaves as a solid rod (with allowance given for the presence of gaps between the wires). Such conditions are referred to as the no-slip (elastic) case. With decreasing curvature, wires in line-contact in various layers (Fig. 1) will gradually undergo frictional transition from no-slip to full-slip condition (and beyond) with an associated decrease in the effective overall strand plane-section effective bending stiffness under cyclic loading accompanied by significant variations in overall hysteresis. The case when all the wires in line-contact have experienced full slippage is, on the other hand, referred to as the full-slip case.

Previous work by others has largely ignored the presence of interwire friction (e.g., Nowak, 1974; Costello and Butson, 1982),

Received December 22, 1992: revised manuscript received by the editors June 21, 1993. The original version (prior to the final revised manuscript) was presented at the Second International Offshore and Polar Engineering Conference (ISOPE-92), San Francisco, June 14-19, 1992.
KEY WORDS: Cable, damping, offshore platforms, vibration, bending.

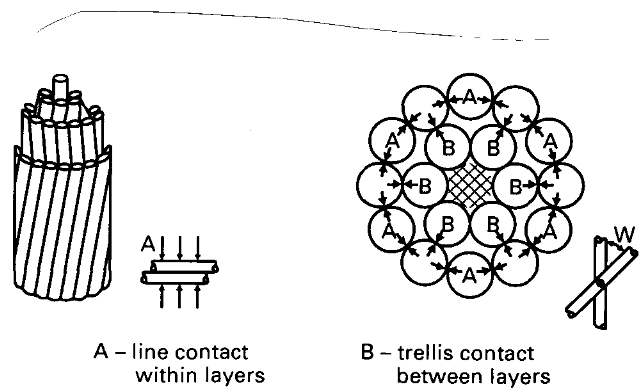

Fig. 1 Pattern of interwire/interlayer contact forces in spiral strands

although some encouraging progress has been made by Lutchansky (1969), Huang (1978), Leclair (1989), Lanteigne (1985) and Feld et al. (1991) to include the effect of interwire friction in their analytical models. A comprehensive review of the frictionless theories is presented by Costello (1990). In view of space limitations, there is little point in attempting a comprehensive literature survey here, particularly when others (Bridge, 1992) have made such surveys very recently. It is, perhaps, worth noting that to the authors' knowledge, none of the published papers, apart from those by the first author, have examined (either theoretically or experimentally) the influence of external hydrostatic pressure on various overall characteristics of sheathed cables.

Apart from a brief description of the salient features of the theory, there is little point in repeating here the often lengthy theoretical derivations or extensive large-scale and carefully conducted experimental work on unsheathed strands, particularly in view of space limitations, and the fact that they have been covered fully elsewhere. Instead, much attention will be devoted to presenting rather straightforward methods for obtaining reliable estimates of various strand free-bending characteristic parameters. These include the no-slip and full-slip plane-section bending stiffnesses