ABSTRACT

The work presents an expression to deal with the stiffness non-linearity of polyester mooring cables. The basis for that is a PhD thesis of the second author and full scale testing of five inch diameter polyester mooring cables. On one hand, weak dependence on the frequency has been detected. On the other hand, the mild to significant dependence on the average load and load amplitude has become clear. Suggestions on how to deal with the expression in a mooring design are also addressed.

INTRODUCTION

The use of polyester in mooring lines of floating structures is a very recent issue due to the oil exploitation in deeper and deeper water. It is nevertheless a reality. After several years of research and field evaluation, PETROBRAS decided to use polyester lines in several Floating Production Systems (FPS) in Campos Basin, offshore Brazil. Two of them have been installed in 1997 and others are planned to 1998.

The basic research that sustained the feasibility of the lines is consolidated in (Del Vecchio 92), where a comprehensive series of testing and analysis is summarized. Typical yarns and small diameter (less than an inch) cables were then studied. Later on, several acceptance tests as required by PETROBRAS have also been performed. Both of these activities yield a fundamental basis for the understanding of the polyester ropes mechanical behavior. The highly nonlinear characteristics have come up clearly as shown in (Fernandes and Castro 97) and summarized next.

THE SPECIFIC MODULUS OF ELASTICITY

The axial stiffness of a line is usually expressed as

\[ k = \frac{EA}{\ell_0} \]  

where \( E \) is the Young Modulus, \( A \) is the cross section area of the polymer cable and \( \ell_0 \) is the initial line length.

This expression works fine whenever the area is not changing too much. For the polyester lines, at least at the investigation stages it is more sensible to work with another quantity that follows after rearranging equation (1)

\[ k = \frac{E A \rho}{\ell_0} = \frac{E d}{\rho \ell_0} \]  

where \( d \) is the mass per unit length and \( \rho \) is the polymer specific gravity. The referred quantity is \( \frac{E}{\rho} \) which is called Specific Modulus of Elasticity.

Following the textile industry, the usual unit for \( \frac{E}{\rho} \) is N/tex, where 1tex = \( 10^{-6} \) kg/m. The advantage of assessing this quantity is that it depends only on material properties, cable construction and the type of loading as shown next. The other ratio in (2) that is \( \frac{d}{\ell_0} \) will come into the calculations at later stages.

COMPREHENSIVE SMALL DIAMETER LINE TESTING

In (Del Vecchio 92) yarns and small diameter polyester cables have been tested in a systematic manner furnishing several informations on the mechanical behavior, inside the present scope. Once the breaking strength was fixed, the line specimen was excited longitudinally with different percentages of average load (\( L_m \)), different load amplitudes (\( L_a \)) and different excitation