

## Damping Linearization for Frequency Domain Lazy-Wave Riser Analysis

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### ABSTRACT

Considering that time domain solutions for the dynamic analysis of a riser are very time-consuming tasks, frequency domain solutions are studied as a possible alternative, mainly in the early stages of a riser design. However, to solve the dynamic riser problem in frequency domain it is necessary to remove the non-linearities, such as, the viscous damping. The aim of this paper is to study and discuss alternatives for the damping linearization and compare the results obtained for a typical lazy-wave configuration with a full nonlinear code results.

**KEY WORDS:** risers; lazy-wave; damping linearization; frequency domain.

### INTRODUCTION

Time domain solutions for the dynamic analysis of a deepwater production riser are very time-consuming tasks mainly if one considers a lazy-wave configuration. The natural periods for such a configuration are considerable greater than the natural periods obtained for a catenary riser installed at the same water depth, which means that the same environmental conditions can excite higher natural modes for a lazy-wave configuration.

Besides that, the axial motions of the upper segment of the riser are weakly coupled with the transversal motions. As the axial damping is very small, it takes a long time to kill the high-frequency transient components in a time domain solution. A possible alternative is to solve the problem in frequency domain, which seems very attractive, mainly in the early stages of a riser design.

To solve the dynamic riser problem in frequency domain it is necessary, however, to linearize the viscous damping and there are many possible approaches to do that. The focus of this paper is to study and discuss alternatives for the damping linearization and compare the results obtained for a typical lazy-wave configuration with a full nonlinear code results.

The coordinate system is presented in the next section, followed by the

models and case study. Finally, the results are presented and conclusions are drawn.

### DEFINITION OF THE COORDINATE SYSTEM

The coordinate system that will be used in the whole paper is defined in this section. X-axis is horizontal, Z-axis is upward vertical and Theta is the angle, as shown in Fig. 1.

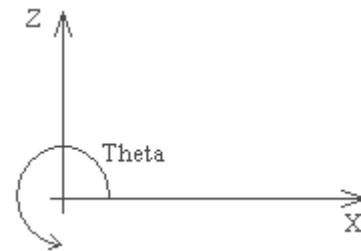


Fig. 1. Definition of coordinate system

### MORISON'S FORMULA LINEARIZATION

Viscous damping is one of the non-linearities of a riser design that must be removed to perform a frequency domain analysis. It can be divided in two parts: transversal and axial. As the axial damping is an order of magnitude smaller than the transversal damping, its effect will be here neglected. The transversal component of the drag force per unit of length is usually obtained by the Morison's Formula:

$$f = -\frac{1}{2} \rho D C_D |v_t| v_t \quad (1)$$

where,  $\rho$  is the density of the fluid,  $D$  is the riser's diameter,  $C_D$  is the transversal drag coefficient and  $v_t$  is the relative transversal velocity.

For a problem without current,  $v_t$  can be considered harmonic,