99/103 Comparison of OrcaFlex with numerical method developed at University of São Paulo for touchdown modelling

1 Introduction

This article is a summary of a paper[1] presented at OMAE 2005. The authors (both from the Department of Mechanical Engineering, University of São Paulo, Brazil) have used OrcaFlex to benchmark a new numerical scheme they have devised for the solution of cable statics with bending stiffness. Agreement between the two approaches is extremely good.

The premise of the study is that numerical integration of the governing set of ordinary differential equations (ODEs) can present stability difficulties when bending stiffness is included. The authors propose to avoid these difficulties by solving the ODEs for an ideal cable, to which they then apply an analytical correction to account for bend stiffness in zones of interest (touchdown, for example).

The authors have already done previous work in this area, based on the case of an ideal cable (one with infinite axial stiffness, zero bend stiffness, and which ignores friction with the seabed). They have shown that numerical integration of the governing ODEs for a 2D model of an ideal cable, corrected with analytic expressions, is very good.

However, in attempting to extend this approach to 3D, the analytic expressions for the bending stiffness correction become too complex and must be solved numerically. Noting that the point of the investigation was to avoid numerical integration if possible, the authors return to tackling the issue of numerical integration of the original set of governing ODEs. They then compare results from this new method with results from an equivalent OrcaFlex model.

2 Numerical integration of Governing ODEs

After outlining the difficulties associated with extending their 2D approach to 3D, the authors discuss integrating this set of equations using standard ODE solvers, and they point out the numerical difficulties discovered in taking this approach.

The authors then present a different scheme to perform the integration. It is based on sequential integration of small lengths of the cable. Taking this approach and performing a stability study, the authors were able to find stability regimes for the proposed method. Having studied this and understood the range of numerical stability, the authors have then proceeded to apply this to a real case.

[1] *A Numerical Method to Solve the Three-Dimensional Static Problem of A Riser with Bending Stiffness*, Lauro Masso Yamada da Silveira and Clovis de Arruda Martins, University of São Paulo, Brazil, OMAE05-67130.

3 Comparison with OrcaFlex

A lazy wave flexible riser is considered. A current profile that changes magnitude and direction with depth was included. The case has been modelled in OrcaFlex as shown below:

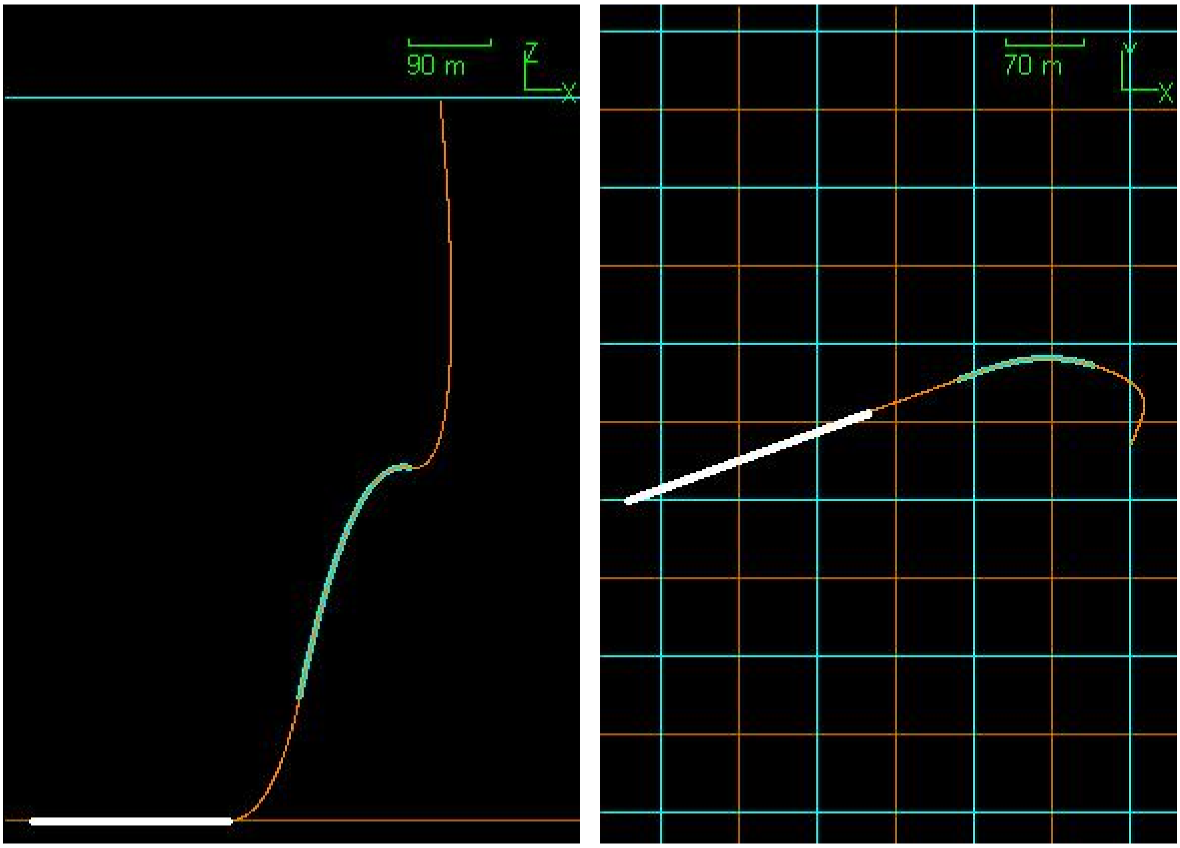

Figure 1: Lazy wave configuration

In Figure 11 of their paper, the authors present an overall range graph of curvature for the whole length of the line. At this scale the curves are barely distinguishable – each curve shown corresponds to results for:

- an ideal cable,
- results from their new method, and
- OrcaFlex results.

Figure 12(a) of their paper shows the same three curvature plots, but with more resolution around the touchdown area - arc length from 225m to 235m (measured from the anchor). It can be observed that even on this very refined scale, differences between the OrcaFlex results and the results from the author's new method are barely perceptible.

In Figure 2 below, we have generated two OrcaFlex curvature results for the same case as presented in Figure 12(a) of the paper (no EI and finite EI). For reasons of copyright, we cannot include the results from the author's new method. However, the curves in Figure 2 herein are identical to those presented in the paper, excepting that the ideal case here shows a small discretisation level slope at the touchdown point.

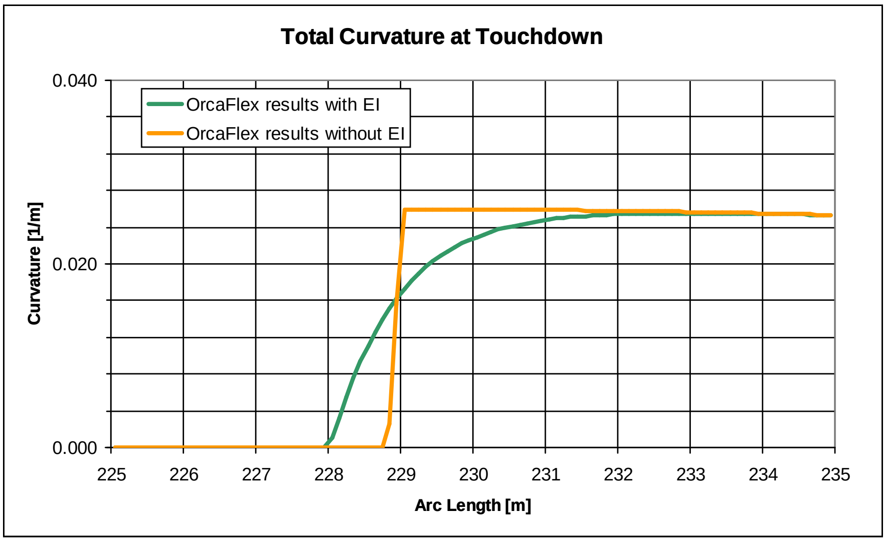

Figure 2: OrcaFlex Curvature Results for Touchdown Zone

There are 3 key points raised in the discussion section of the paper:

a) Numerical integration of the ODEs allows the inclusion of bend stiffness to be accounted for.

b) When compared with OrcaFlex, the same results are obtained. To quote the authors: “This is an important fact, as the same results were achieved by two distinct numerical methods.”

c) Computation time for numerical integration of the ODEs describing the static problem was 2 hours on a P4 3.2GHz computer, compared to a few seconds in OrcaFlex. The authors are not offering their model for practical use, rather as an illuminating academic exercise.