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A COMPARISON OF DIFFERENT APPROXIMATIONS FOR COMPUTATION OF SECOND ORDER ROLL MOTIONS FOR A FLNG

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ABSTRACT

The use of FLNG units for gas exploration and production offshore is a subject in study by some oil companies. More complex and sophisticated than a FPSO production plant, a gas production plant has strict motion criteria in order to have an optimal operational performance. Due to this, designers have been trying hull concepts with small initial stability and higher roll motion periods in order to reduce the unit motions and improve the plant performance. Indeed, the increase of roll natural period dramatically reduces the first order roll motions. However, the unit still responds at its resonance due to second order excitation. These kinds of loads are also more complex and require a great computational power to be evaluated. Due to its complexity, which would involve the solution of a non-homogeneous free surface boundary condition, some approximations are used in order to assess the second order loads and motions. In this paper, the different formulations for the first part of QTF, contributed by first order quantities, are revisited and the differences are highlighted. Furthermore the approximations for the computation of the second part of the QTF, contributed by the second order potential, are benchmarked for the case of a FLNG operating in deep water depth.

INTRODUCTION

The offshore production at Brazilian pre-salt reservoirs presents several challenges, regarding drilling, production at ultra deep water and gas treatment. For some scenarios with a large amount of gas, the production and trading of the product might be an attractive option, which minimizes the environmental and economical impact of burning. One alternative to treat and commercialize this gas might be having a Floating Liquefied Natural Gas Unit (FLNG) with a gas process plant to process and liquefy the gas. A process plant to treat gas offshore has more operational constraints than a traditional FPSO Unit, including smaller maximum inclinations (combining Roll and Pitch motions) which requires a hull with very small dynamic responses.

Some studies for this kind of units have been performed by some operators, like Shell and Petrobras, and it became clear that a very large unit is necessary to guarantee a high level of operability. Besides that, the unit also needs high roll motions natural periods in order to attend the dynamic requirements of the gas process plant.

Indeed, the high natural period will dramatically reduce the first order roll motions as it will fall out of the range of the incident waves' periods. Nevertheless, it will not prevent the unit to present significant resonant roll motions due to second order effects.

Second order loads require, in general, higher engineering expertise to be evaluated. The estimation of second order roll moments, in particular, induces additional complications, notably the computations of loads at high differences of frequencies. Due to the complexity in computing the complete second order loads, which would involve a non-homogeneous free surface boundary condition, different approximations are used in order to provide an estimative of these loads.

Furthermore, most of the work on second order wave loads has been dedicated to horizontal plane for the purpose of assessing mooring systems. There are only few references on vertical second order loads, as the work presented in Chen & Molin

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