Influence of ballast material on the buoyancy dynamics of cylindrical floaters of FOWT

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Structural Model

The FlowDyn structural FEM model is based on a non-element depending Corotational internal loads approach, based on a formulation derived for dynamic analysis [1]. Corotational local axes for shell elements are based on a drift correction angle [2], known as Linear Triangle Best Fit.

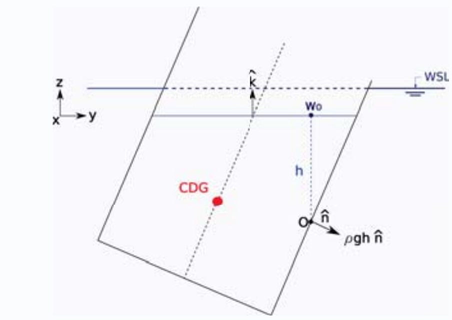
The dynamic analysis is performed in the time domain by solving the equations of motion of the system, based on the Newton's 2nd law. For the time integration a alpha-Generalized Method [3] scheme is adopted in combination of an iterative Newton-Raphson method to deal with the nonlinearity.

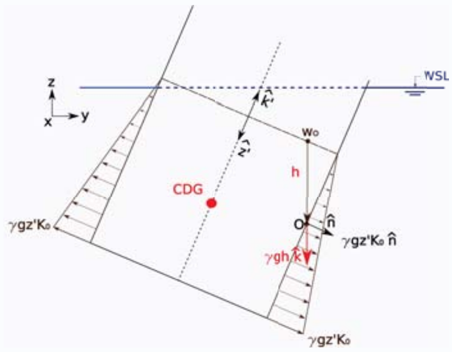
The model presented allows to compute the displacements field at mesh nodes and internal loads over all the geometry by a nodal interpolation computation.

Ballast Model

Offshore structures are usually ballasted with granular materials or water. The different behavior of these materials modifies the structure motion depending mainly on its geometry. The granular ballast model is defined by a constant radial At-Rest pressure and a weight component, which depends on the material column over each shell element. For liquid ballasting, an hydrostatic internal fluid pressure law is applied, computing at each step the new position of the free surface.

Both models deal with inertial loads by distributing the ballast mass and inertia over the most close nodes.



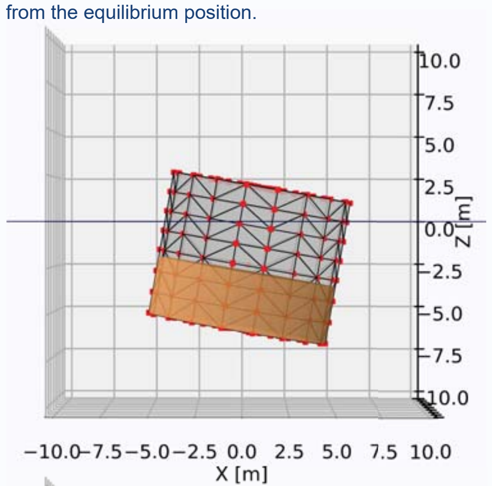


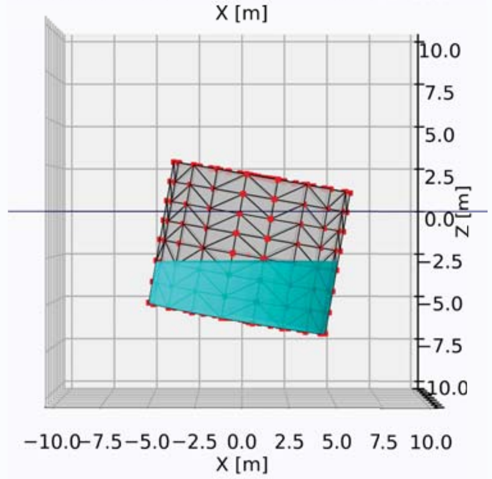
Granular ballast model is reduced to rotations smaller than the internal friction angle, to ensure that free surface remains parallel to the base. For liquid ballast, only a vertical hydrostatic distribution is applied, thus the structure needs quasi-static movements with low inertial accelerations and also with a frequency movements far enough from sloshing phenomena, which is no modeled in this approach.

Simulation Models

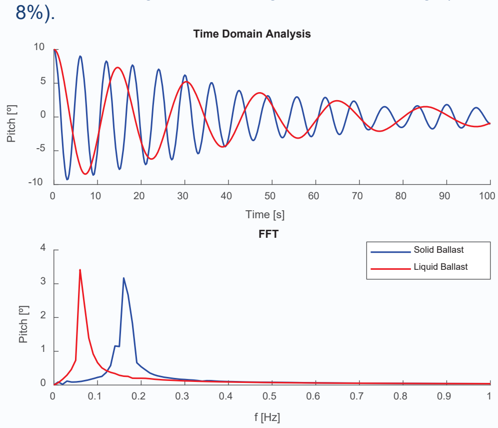
In order to compare the model behavior over different geometries, two pitch free decay analysis have been performed. For comparison reasons, same mass and density of the ballast materials are considered.

The first analysis is based on a cylinder of 8m height and a radius of 5m, with an initial rotation of 10 degrees from the equilibrium position.

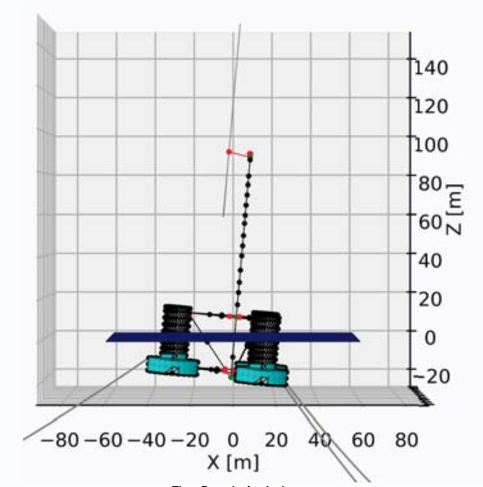


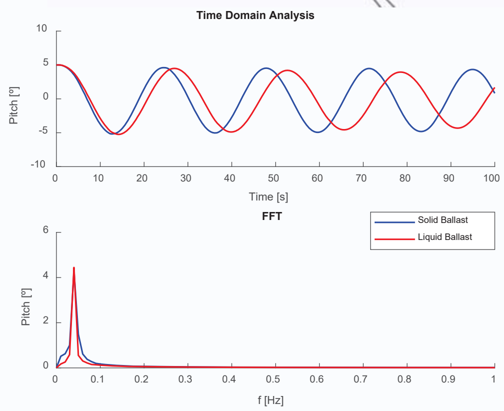


Due to the cylinder geometry, the effect of the liquid ballasting produces a considerable increasing of the pitch period of the structure. Also an amplitude increment of the related frequency is noted considering liquid ballasting instead of granular ballasting (about 8%).



Second simulation is based on a FEM model of the DeepCwind semisubmersible platform, composed of 48 beam and 2592 shell elements. The initial pitch rotation is fixed in 5 degrees from the equilibrium position.





In this case, the influence of the ballast model is less accused than in the cylinder due to the geometry of the platform, but as shown in time domain analysis, the period of the platform is slightly shifted and also the amplitude associated increases about 4% with liquid ballasting.

Conclusions

The results obtained show that the platform dynamic behavior is affected by the nature of the ballast. The geometry of the platform and also its dynamics are related with the differences noticed.

Then, further studies are expected to better assess the range of these effects.

References

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