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Published in:
Computational Geomechanics I : ComGeo I

Publication date:
2009

Document Version
Publisher's PDF, also known as Version of record

LUMPED-PARAMETER MODEL OF A BUCKET FOUNDATION

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ABSTRACT

As an alternative to gravity or pile foundations, offshore wind turbines can be placed on a bucket foundation (Ibsen 2008). The bucket foundations, often referred to as "suction caisson", are large cylindrical structures, typically made of steel. The bucket consists of a vertical skirt extending down from a horizontal base resting on the soil surface. The bucket is installed by means of suction. When the bucket foundation has been installed, the loads from the wind on the wind turbine will cause the foundation to be influenced by a large moment. The stability of the foundation is ensured by a combination of earth pressures on the skirt and the vertical bearing capacity of the bucket. The bucket foundations have the potential to be the cost-effective option for future offshore wind farms, if suction assisted penetration is employed.

The bucket foundations fall in the category of thin shell structures. The present analysis concerns the development of consistent lumped-parameter models for this type of foundations (Liingaard 2006; Andersen 2008). The aim is to formulate a computationally efficient model that can be applied in aero-elastic codes for fast evaluation of the dynamic structural response of wind turbines. The target solutions, utilized for calibration of the lumped-parameter models, are obtained by a coupled finite-element/boundary-element scheme in the frequency domain (Andersen 2002), and the quality of the models is tested in the time and frequency domains. It is found that precise results are achieved by lumped-parameter models with two to four internal degrees of freedom per displacement or rotation of the foundation for frequencies below 2–10 Hz. Due to the embedment in the ground, coupling between the horizontal sliding and rocking cannot be disregarded without significant loss of accuracy.

Finally, attention is drawn to the influence of the skirt stiffness, i.e. whether the embedded part of the caisson is rigid or flexible. It is found that the steel bucket foundation may be regarded as a rigid embedded foundation, regarding the vertical and torsional excitation. However, the finite stiffness of the skirts must be accounted for in the high-frequency limit in order to obtain a well-behaved lumped-parameter model.

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