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Tuning the Air Pressure of Aircushion Supported Structures at Model Scale

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ABSTRACT

To allow transportation of bottom-founded offshore structures from a shallow building dock to deeper water, the draft of some structures is temporarily decreased by pumping compressed air underneath the construction. At the final location, the air is released and the structure is installed on the seabed. Motion behaviour and stability change when air escapes from the cushion underneath the structure.
This paper describes the change in motion behaviour of an aircushion supported structure at different drafts. Calculations are performed based on linear three-dimensional potential theory using a linear adiabatic law to describe the air pressures inside the cushions. The water surface within the aircushion and the mean wetted surface are modelled by means of panel distributions representing oscillating sources.
Results of model tests of an aircushion supported structure at a constant draft are included and serve as a validation of the computational method. The description of the motion behaviour also includes a discussion of the heave added mass, damping, cushion pressure variations and structural loads.

KEY WORDS: Aircushion support; motion behaviour; air pressure; structural loads; wave bending moments.

INTRODUCTION

The use of aircushions to support very large floating structures, although only used in few applications, has been known for a long time in the offshore industry. In most of these cases the draft of a bottom-founded structure was temporarily decreased by pumping compressed air underneath the construction to allow transportation from a shallow building dock to deeper water.
The Khazzan Dubai oil storage tanks installed in Arabian Gulf in 1969 were probably the first large floating offshore structures passively supported by air. Chamberlin (1970) and Curtis et. al. (1970) described the design, construction and installation of Khazzan Dubai oil storage tank No. 1. Eventually this structure was joined by two sister structures in the early seventies. In order to float these open-bottom structures and towing them from the construction yard to the final location 60 miles offshore, air was pumped underneath the roof of each structure and pressurized until it supported the weight of the unit.
Once on location, the structure was submerged by venting the air under the roof. The sudden release of air reduced the pressure and the unbalanced weight of the structure caused a dynamic descent. The process continued with an increasing draft and angle of tilt up to 22 degrees until the structure was supported by its centre bottle. Each unit contained an internal bottle shaped tank as an integral part of the structure which was employed to maintain stability during submergence. Submergence continued by pumping water into the bottle as described by Burns et. al. (1972).

Another example is the installation of the Maureen Gravity platform in 1983 as described by Berthin et. al. (1985). During this operation compressed air was pumped underneath the bottom to float the 42,600 tonnes structure. The platform was finally towed out of the dry dock on its aircushion with a draft of 9.1 metres.
Aircushions were also used to lift the 218,000 tonnes bottom section of the Gullfaks C Condeep structure to a buoyant condition from the construction dock in 1987. About 96% of the buoyancy was provided by aircushions during this operation. The use of air to improve the floatability of the structure was also used on the first Condeep's in 1974. To some extent aircushions were used in all subsequent Condeep projects as described by Kure and Lindaas (1988).

The behaviour of large aircushion supported structures in waves was studied by Pinkster et. al. (1997 ~ 2001) and Van Kessel et. al. (2007) at Delft University of Technology. Model tests carried out by Tabeta (1998) in the towing tank of the Ship Hydrodynamics Laboratory served to validate the results of the computations. Pinkster (2001) and Meevers Scholte (1999) also performed model experiments of a large aircushion supported Mobile Offshore Base (MOB) in 1999. During these model tests, air escaped underneath the structure at high sea states, which was due to the fact that wave troughs were deeper than the draft of the structure. As a result the volume of the aircushion decreased and consequently the draft of the structure increased. This