

## Simulation-based Analysis of Spudcan Interaction with Soil

C Cai, JY Guo, XM Tan and ZS Liu

Institute of High Performance Computing  
Singapore

### ABSTRACT

The nonlinear structure dynamic analysis code LS-DYNA is utilized to analyze the soil-spudcan interaction in three dimensions in order to predict the fixity of the spudcan sitting on the seabed. The present paper describes a practical procedure to predict the fixity of spudcan footing of jack-up rigs and summarizes some important issues which may affect the accuracy of simulation results of the soil-structure interaction, such as sand properties, the extent of soil domain and the subsidence of sand under gravitation.

In addition, it is demonstrated that how to model and use the seabed sand properties in numerical models is crucial on the accuracy of the simulation results. The simulation results of soil-spudcan interactions and knowledge-sharing in relevant simulations will benefit to the design of jack-up units as well as the site specific assessment of mobile jack-up units.

**KEY WORDS:** Spudcan; offshore; fixity; interactions; simulation.

### INTRODUCTION

As a mobile tool for drilling operations of oil & gas industry in shallow water, jack-up units have been used for several decades. Typical jack-up units consist of a buoyant triangular platform resting on three independent truss-work legs, with the weight of the deck and equipment almost equally distributed.

During jack-up installation, it is towed to the site by floating on the hull with the legs elevated out of the water. On the location, the legs are lowered to the seabed, where they continue to be jacked until the hull climbs out of the water. The foundations of the seabed are then pre-loaded by pumping sea-water into ballast tanks in the hull, as shown in Fig. 1. It is usual for the total combined pre-load (*i.e.* jack-up mass and sea-water) to be around double the mass of the jack-up. The ballast tanks are emptied before operations on the jack-up begin.

Generally, the footings of independent-leg jack-up look like large inverted cones known as 'spudcans'. The spudcans will penetrate several meters into the seabed during pre-loading process. In a perfectly calm sea, vertical self-weight is the only loading being applied on the spudcans. However, during a storm, environmental wind and wave forces impose additional horizontal loads and moments onto the foundations of the jack-up. An understanding of spudcan interaction with soil under these combined load conditions is essential to the analysis of jack-up response.

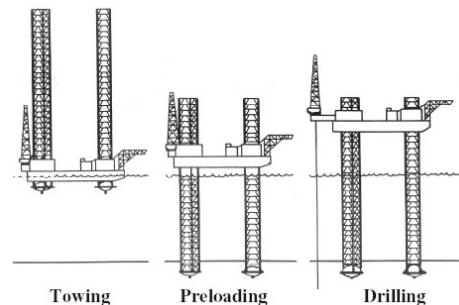


Fig. 1 Jack-up installation procedures

In recent years, there has been much interest in the level of foundation fixity developed by spudcan footings because critical member stresses (usually at the leg/hull connection) and other response values may be reduced if some foundation fixity is taken into account. Conventionally, due to complicated sand conditions, inherent soil-structure interactions and various environmental loadings, it is of a great difficulty to determine fixity of a spudcan on seabed. As a result, an assumption that the leg-ends of a jack-up structure are pinned onto the seabed usually has to be made when one performs the strength assessment for the jack-up structure. It is noted that this assumption leads to a very conservative design for jack-up structures because the stresses of legs for pinned conditions are much higher than the cases where the leg ends of structures are fixed onto the seabed. However, in practice, a spudcan may provide certain moment fixity which has been proved by a lot of