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An Investigation of Extreme Wave Behaviour Around a Model TLP

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ABSTRACT

This paper presents further results from an investigation into the response of TLPs in extreme waves. Using a scale model of the *Heidrun* TLP in a wave basin, the wave behaviour around the model in regular waves of various frequencies, heights and approach angles was recorded using wave gauges and video cameras. These revealed considerable wave runup on the columns, wave-height amplification under the deck and waterspouts. A selection of the results obtained is presented here.

INTRODUCTION

As waves pass a cylinder, partially-immersed vertically in the water, the cylinder will, to a lesser or greater extent, experience *runup* and *drawdown* around its circumference. By this, the maximum heights and depths that the water reaches to on the surface of the cylinder are in excess of the crest and trough amplitudes respectively of the undisturbed wave train. In addition the cylinder reflects a proportion of the wave energy, which then meets and interferes with the approaching crests. Where this interference is constructive, the wave steepens and its velocity field becomes increasingly nonlinear. Many investigations, for example by Hallermeier (1977) or Tørum (1989), have been concerned with the implications for the prediction of forces on such single, surface-piercing columns.

However, offshore platforms usually incorporate multiple-column geometries. Hydrodynamic interference between the columns results in intensification of the behaviour mentioned above, both in front of the platform and under its deck. These have important implications for the design of the air gap between platform and water, which is governed by the maximum local wave amplitude. For a TLP or semisubmersible, the design of the air gap is critical due to weight and stability considerations, but the possibility of wave impact (slamming) on the underside of the deck must also be minimised. This is complicated by the inverted-pendulum motion of a TLP, which gives rise to the setdown of the platform relative to the water surface, thus reducing the air gap. Although slight, this should also be accounted for in the choice of air gap.

Investigations using TLP configurations by Owen and Padilla Perez (1987), Eatock-Taylor and Sincock (1989) and Niedzwecki and Huston (1992) found that the local wave heights could be amplified by a factor of up to 2 in regular waves and by approximately 10% in random seas. For a given wave period, the ratio of runup on a forward leg to that on an aft leg was found to increase with decreasing column spacing. Additionally with decreasing column spacing, the maximum amplitude of upwelling under the deck and the wave period at which the maximum occurred were found to increase. An investigation by Bruce and Easson (1997) into local amplifications of wave height between pairs of cylinders found jets of water erupting from the surface between the cylinders. To investigate whether this particular phenomenon should be considered in the design of offshore platforms, the investigation is currently being extended to semisubmersible platforms in association with the present authors.

Natvig (1994) has shown that ringing forces are affected by vertical shifts in a TLP's centre of gravity, ergo the choice of the design air gap will, to some extent, affect the transient forces acting on a TLP. An experimental investigation by Incecik et al. (1996) studied these higher-order forces and the wave conditions which produced them, using a scale model of the *Heidrun* TLP. Also observed during these tests, however, were significant amplifications of wave height under the deck and jetting upstream of the model. Therefore further experiments were performed to examine these phenomena more closely, results from which are presented in this paper.

EXPERIMENTAL ARRANGEMENT

Model TLP

The model TLP used in the experiments was a 1:98.4 scale model of the *Heidrun* TLP. The model, shown in Figs. 1a~c, incorporates 4 circular cylinders for its supporting columns, scale replicas of the tether balconies being incorporated at their bases. Connecting the bases of adjacent legs are pontoons of rectangular cross-section. The deck is made from a sheet of plywood, 25 mm thick, although the air gap is not scaled, that of the model being less than that of the full-size platform. Stiffening for the model structure is provided by a steel-tube frame running throughout.

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