Novel scaled physical modelling of wave loading of offshore wind turbine towers and foundations using centrifuge technology

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Experimental studies of wave loading of offshore structures typically involve wave simulation in flumes under 1g conditions. Very large flumes are required for problems of practical significance, unless scaled down and if the objective is to investigate soil-structure interaction (with a model seabed), this leads to difficulties in simulating soil responses. Geotechnical centrifuge experiments utilizing scaled models in high gravity environments can create correctly scaled soil stresses and are also suitable for modelling the fluid waves. Over the last few decades, conventional beam centrifuges have been used to generate solitary, standing and progressive fluid waves to study coastal erosion, wave loading on coastal/offshore structures, instability of pipelines and wave-induced liquefaction of seabeds. However, the reduced length of test boxes in beam centrifuges limit wave characteristics and create challenges with attenuating reflected waves.

A drum centrifuge offers many advantages compared to a beam centrifuge and in particular, a much longer testing channel around its circumference is useful for fluid wave generation. Devices for wave generation must also account for high centrifugal accelerations and the necessary high frequency of waves. Incident waves generated by the wavemaker/flume walls must be dissipated in the centrifuge channel without reflections, to achieve high-quality data and different passive wave absorbers have been tried (e.g. slotted caissons/beaches) with varying degrees of success. An alternative is an ‘active’ paddle wavemaker absorption system, which minimizes the re-reflections by modifying the control signal for the wave generator (known as reflection compensation).

In this paper, the principle of wave generation in a geotechnical centrifuge will be presented and the new active fluid wave generation system in the large drum centrifuge at Western University will be described. Its application with respect to physical modelling of wave-induced forces on offshore wind turbine towers and foundations installed in shallow water will be discussed in detail.