Accidental drop of slender cylindrical bodies, a numerical and experimental study of velocity and trajectory of cylinders falling through water

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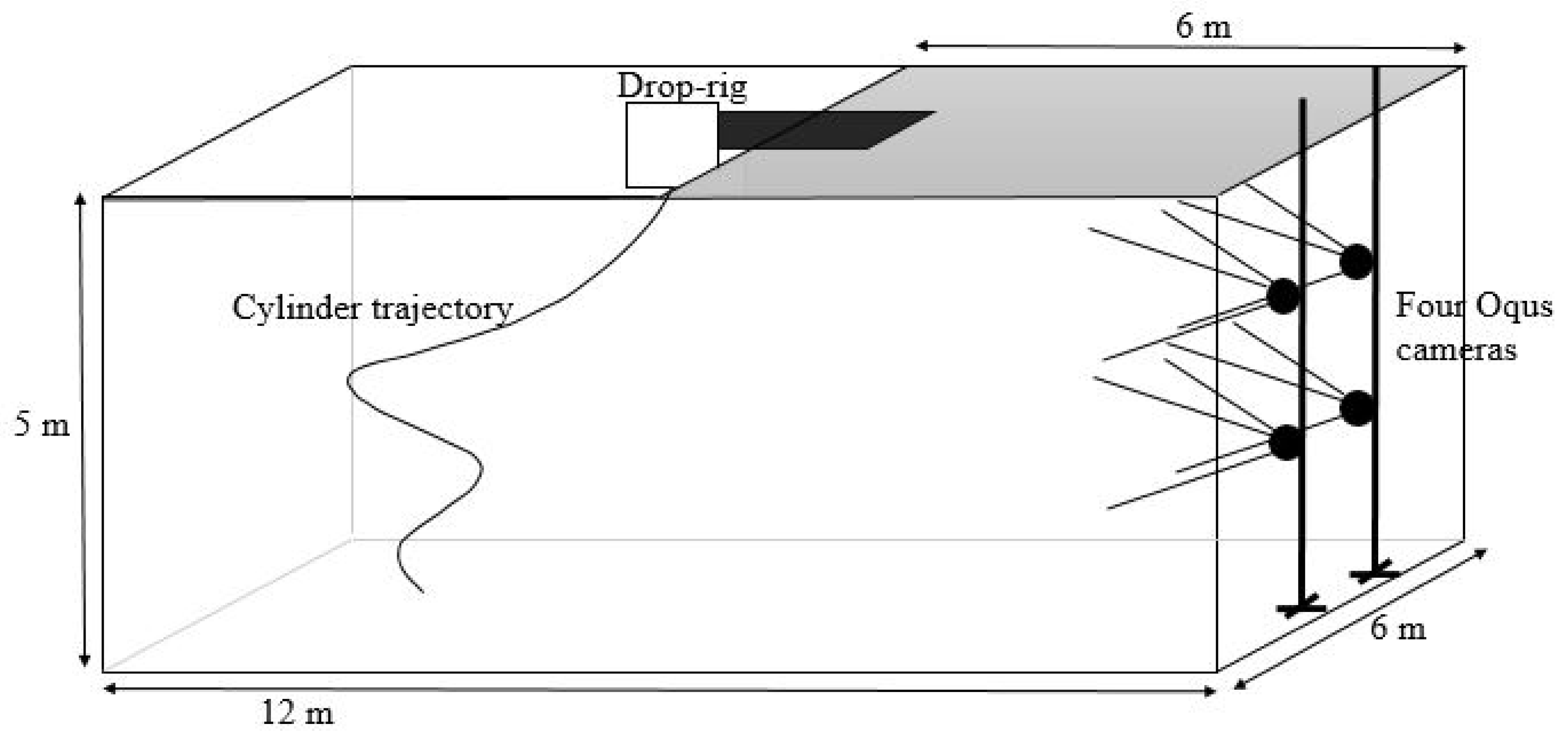
Introduction

The oil and gas industry is continuously working to improve safety and minimise risk. Numerous offshore activities involve risks that may lead to accidents with serious consequences. The risk of accidental dropped objects, e.g. related to crane operations, is one of the most common threats during offshore operations. A falling object is of concern due to human safety, the environment and dangers related to damage to subsea structures and operational equipment.

Method

Drop experiments were conducted in Dokka, a tank owned by SINTEF Ocean. The positions of the cylinders through the falling motion, were tracked by a Oqus camera system. Oqus are high speed motion capture cameras capable of tracking a marker position through a three dimensional motion. A simulation program for falling slender objects was made in MATLAB. The program was based on a simple two dimensional theory derived from manoeuvring equations and corrected for viscous effects.

The experimental set-up



Objective and scope

The purpose of this thesis is to analyse and investigate slender cylindrical objects behaviour, for instance drill pipes, when falling through air, entry into the water phase and their travel through the water column. The main focus is however, the fully submerged condition. The velocity and trajectory of falling cylindrical objects into and through the water column are investigated through numerical calculations and experiments. Seven different cylinder types were tested. The control parameters are the cylinders physical parameters (length to diameter ratio, centre of mass location, open or closed ends) and the initial drop conditions (drop angle and drop position).

Conclusion

- The centre of gravity locations and the drop angles have the largest influence on the trajectory
- Cylinders with a small displaced centre of gravity had the largest excursion and bottom impact velocity
- Good agreement between numerical and experimental results were found, but was found to be depend on the chosen value for the trailing edge position and the lateral drag coefficient.
- The viscous force was found to be more dominant in the lateral, than in the axial direction.
- Cylinders with open ends reached lower radial

Results

Six different types of trajectory patterns were detected. The following figures show some examples of trajectories found from the experiments.

Figure 1: Effect changing the drop angle

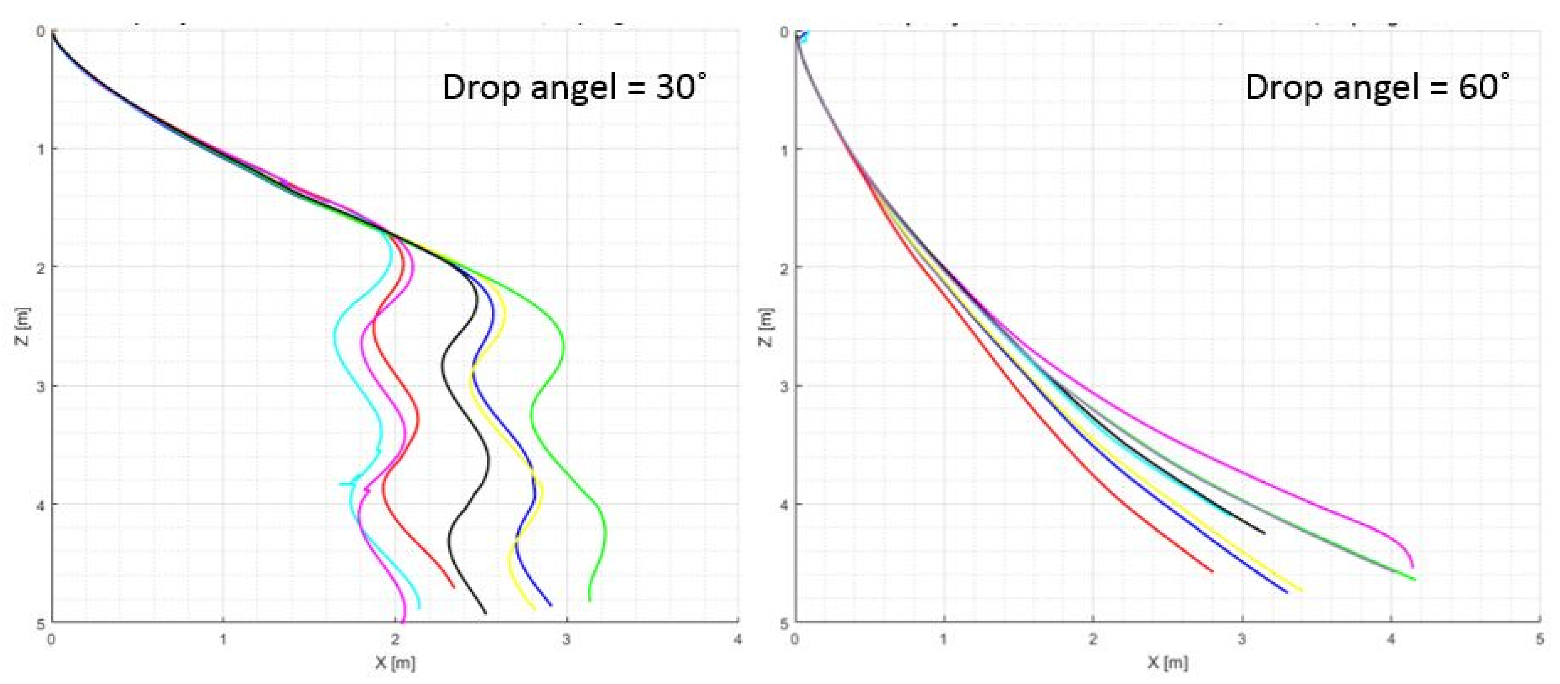
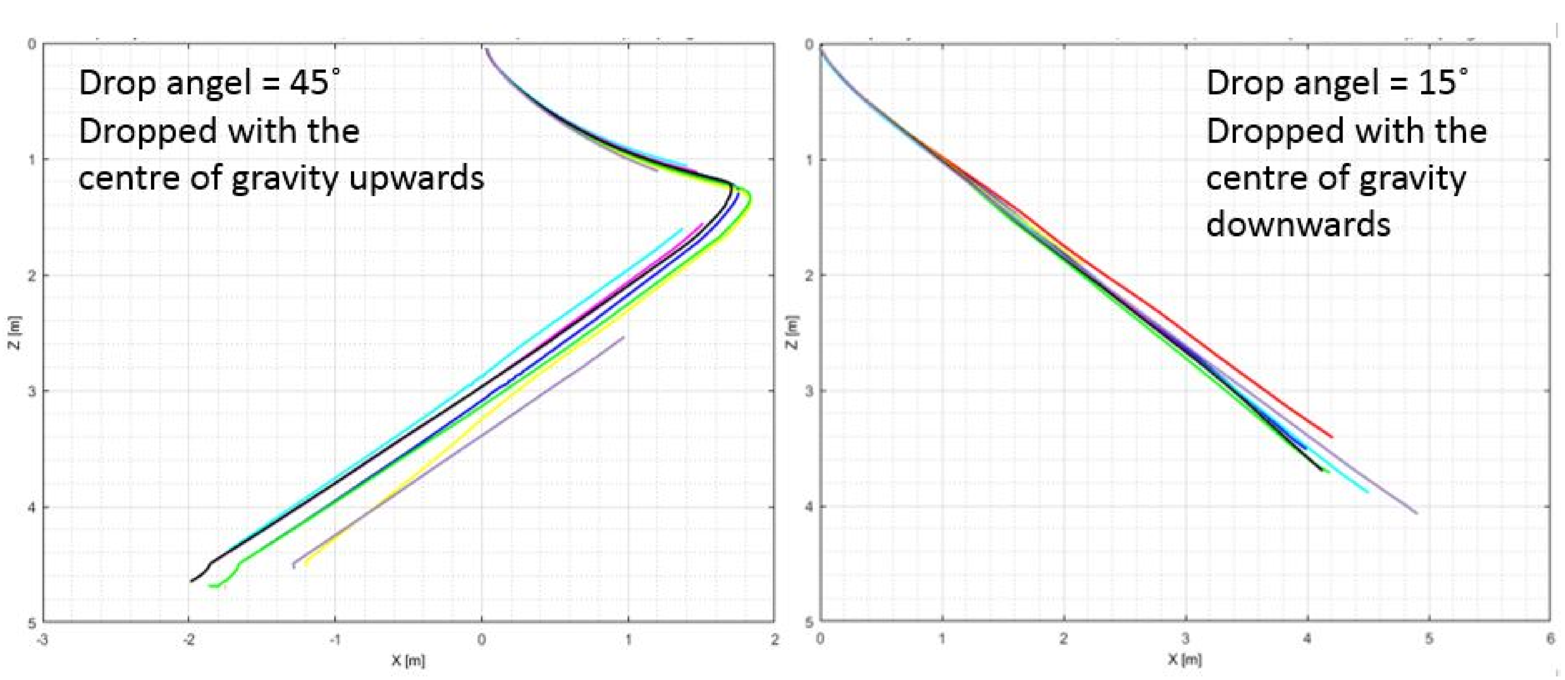


Figure 2: Trajectory for cylinder with displaced centre of gravity



To the right in Figure 3, the velocity for an ordinary cylinder is showed, and to the left, the velocity for a cylinder with displaced centre of gravity dropped with the centre of gravity downwards is showed. Figure 4 shows a comparison between the trajectories found from the experiments in black and the simulated trajectories with coloured lines. To the right in Figure 4, the effect of changing the effective trailing edge position is illustrated, and to the left the effect from changing the transverse drag coefficient is showed.

Figure 3: The velocity as a function of depth for initial drop angles 15°, 30°, 45°, 60° and 75°.

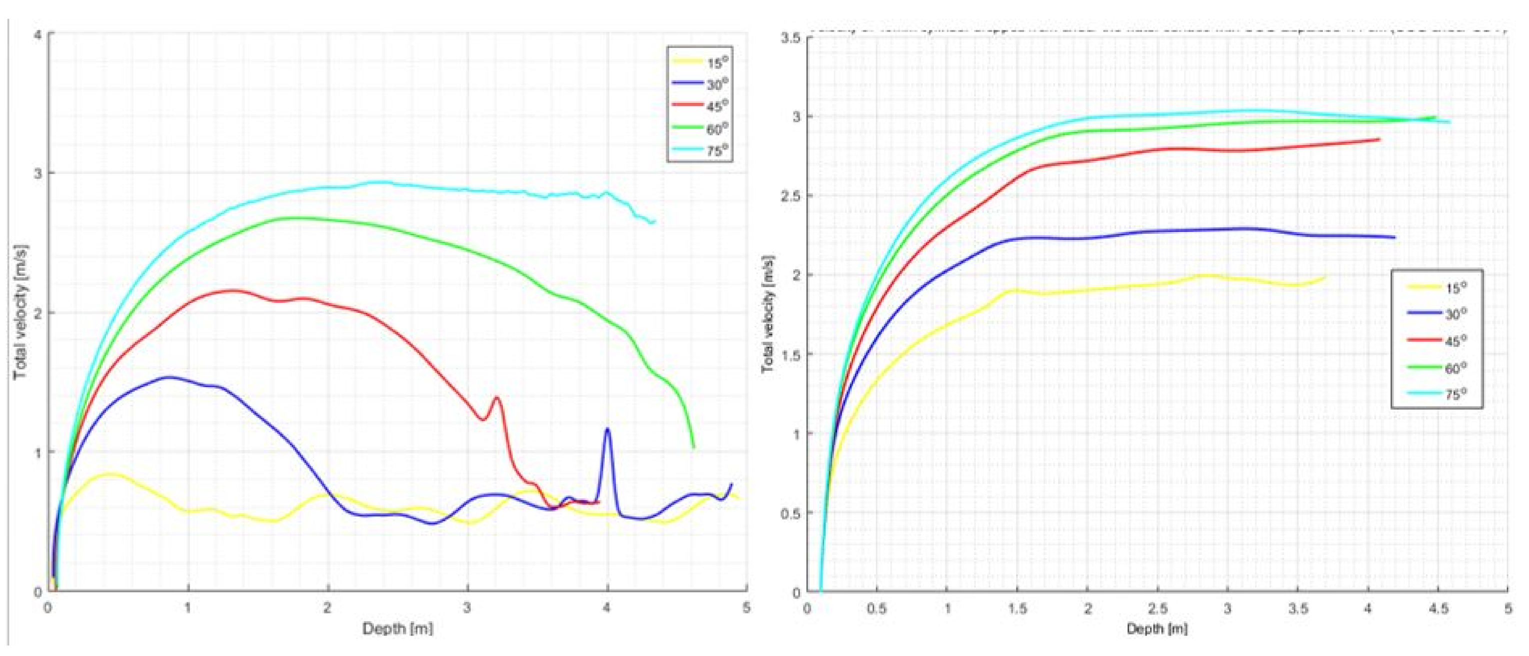
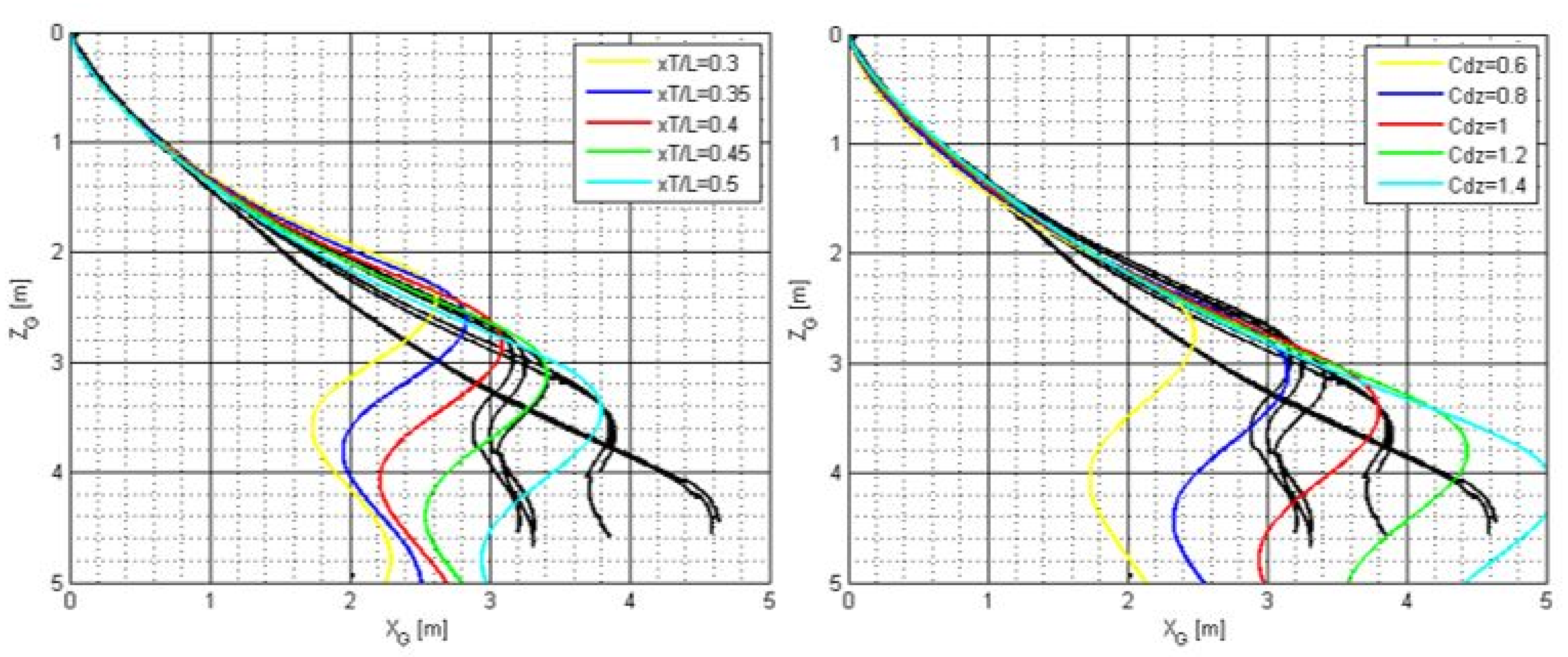


Figure 4: Comparison between simulations and experiments for drop angle equal 45°.



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