Experimental Investigation of the Motion of Accidentally Dropped Slender Bodies

NTNU
Norwegian University of Science and Technology

Frid Grøtterud Birkeland
Supervisor: Prof. Trygve Kristiansen   Co-supervisor: Hagbart Skage Alsos

Introduction

Impact of falling objects underwater can result in critical damage on pipelines, platform base structures and underwater installations. This has to be accounted for during offshore operations and installations. Slender, cylindrical objects are of particular interest as these can get large excursion from the drop point dependent on the angle of the object as it pierce the water surface [1]. Examples of slender body types are drilling pipes or weight tubes and limited experimental investigation have been performed on the subject.

The motion is dependent on the geometry, weight and weight distribution of the slender object, and the angle of attack as the object pierce the surface. The theory describing this motion have been described earlier research projects. [1]

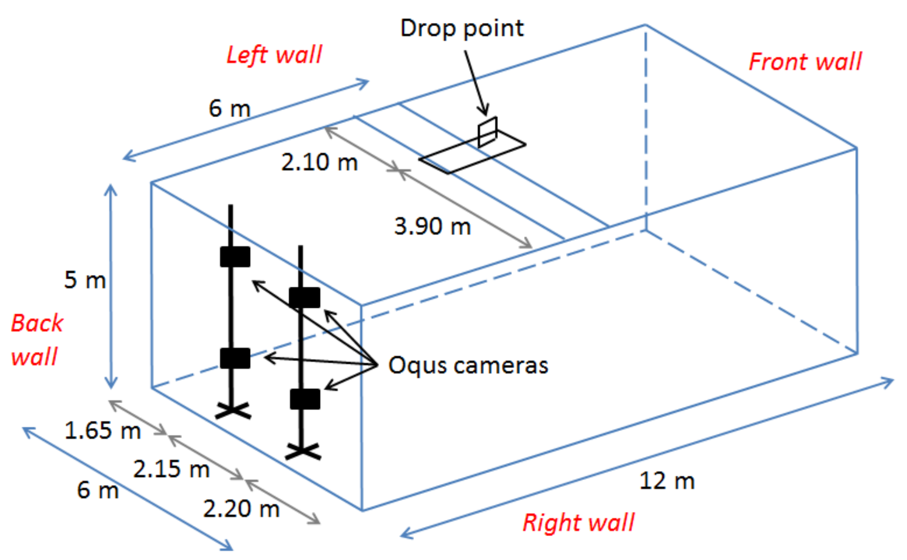
Objective and Scope

The objective is to study the motion and development in velocity of slender cylinders when dropped above and underneath the water surface. This include open and closed geometrical symmetric cylinders with variation in diameter, and cylinders with the **Centre of Gravity (COG)** displaced 3% and 7% of the full length from the **Centre of Volume (COV)**. The results from the experiments will be compared to simulated results from a script based on theory by [1] to determine the accuracy of this theory. It is assumed that environmental forces such as current, waves and wind, are absent.

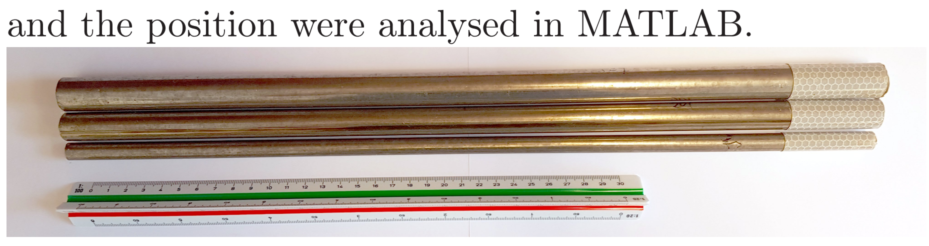
The experiments have been performed in collaboration with Helene Salte Håland.

Methods

The experiments were performed in the tank Dokka, at the Centre of Marine Technology. The set-up and dimensions of the tank is illustrated in the figure underneath.



Drops have been performed above the surface for capped cylinders with length 45 cm and diameter from 10 mm to 19 mm (figure underneath). Drops underneath the surface were performed with these cylinders, open cylinders with the same dimensions as given, and with cylinders with COG shifted 1.4 cm and 3 cm from the COV. All cylinders have been dropped with angles from 15° to 75° with the surface. The motion for each time step for each cylinder were captured by a Oqus Underwater System and the position were analysed in MATLAB.



In addition a simulation program was made in MATLAB from already known theory on the subject [1] in order to check the accuracy and validity of this theory.

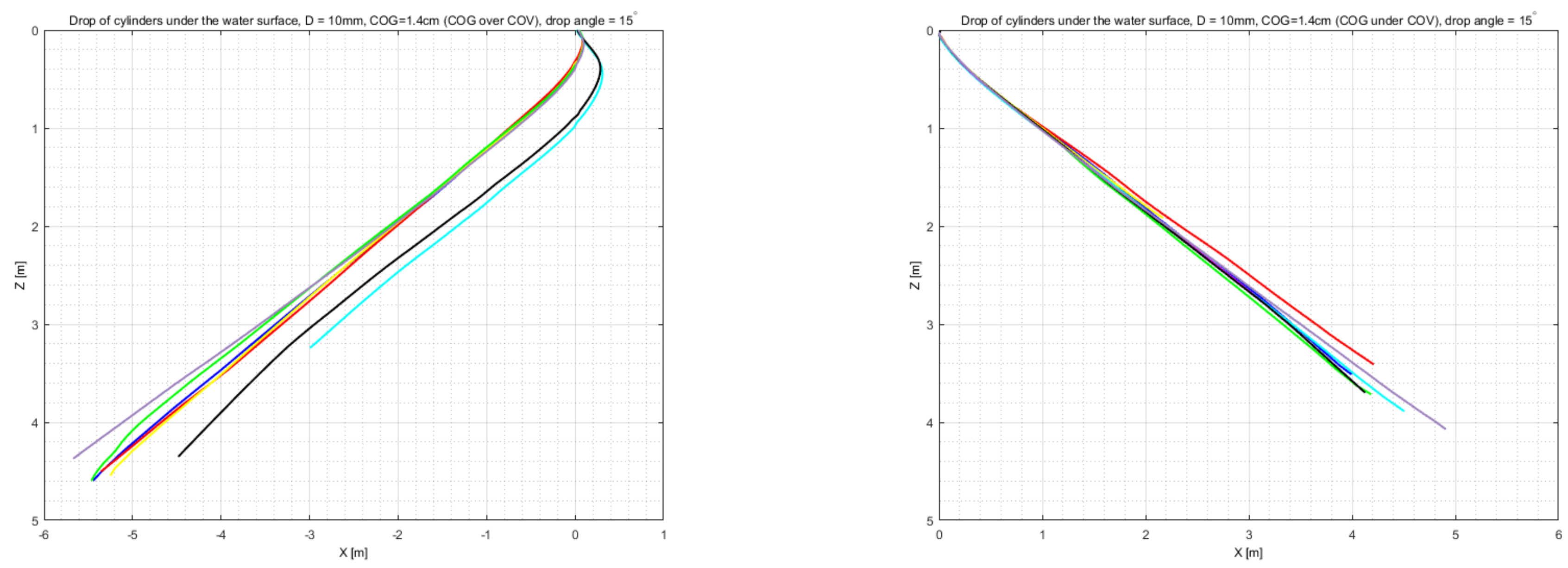
References

[1] V. Aanesland: *Numerical and Experimental Investigation of Accidentally Falling Drilling Pipes*, 19th Annual Offshore Technology Conference (1987)

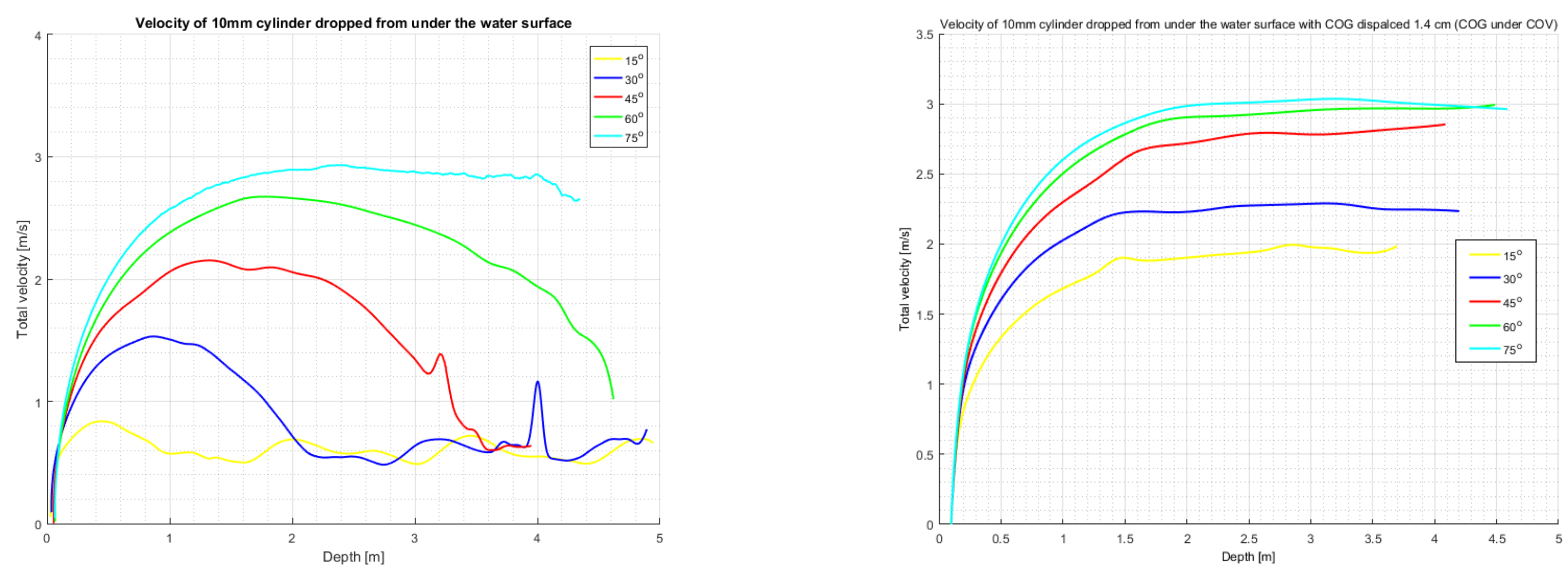
Results

The following figures represent a selection of the most interesting results from the experiments and simulations.

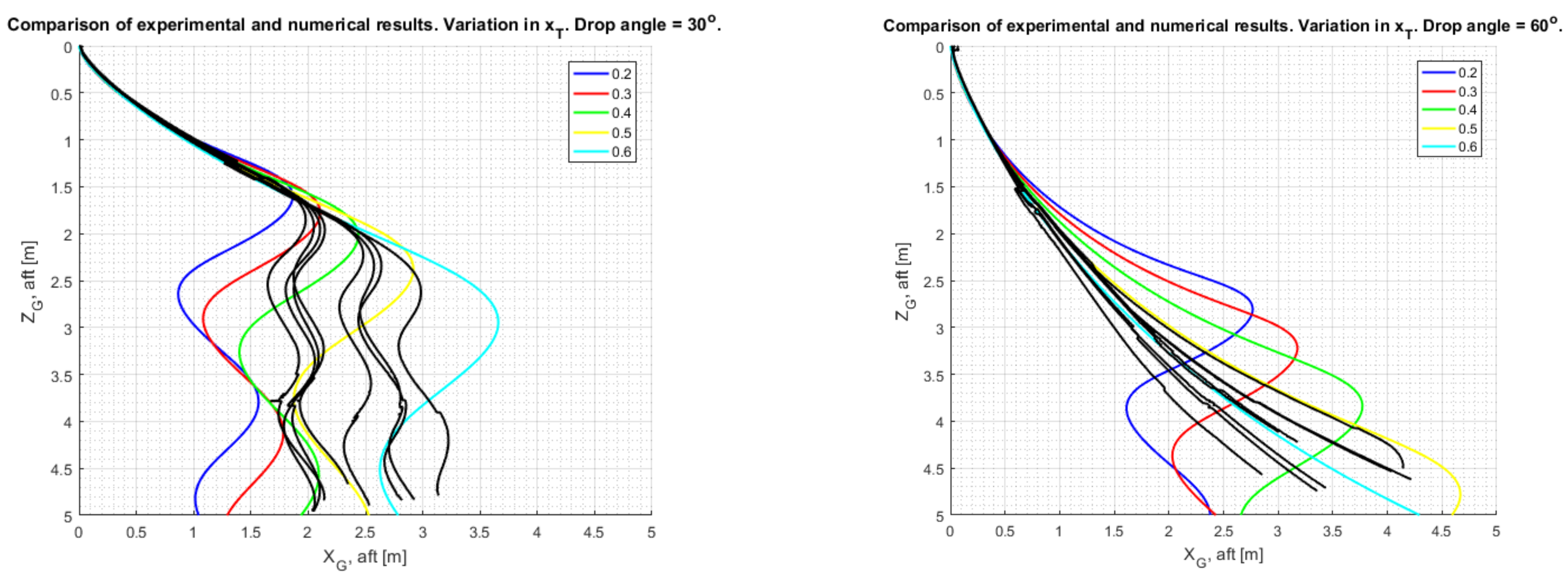
The figures above show the trajectories in the XZ plane of closed, symmetric cylinders with drop angle 30° with the surface. The figure to the left have diameter 10 mm and the figure to the right 19 mm.



The figures above show the trajectory for cylinders with Centre of Gravity shifted 1.4 cm from Centre of Volume. In the figure to the left has COG higher than COV, resulting in a turn before gaining a straight path.



Both figures above illustrate the development in velocity compared to depth for different initial drop angles. The left is for a symmetric cylinder with diameter 10 mm, and the right is for a cylinder with COG 1.4 cm from COV.



The two figures above show the agreement between the experimental results (black lines) for drop angles of 30° (left) and 60° (right), compared to simulated results with variation in trailing edge, x_T. x_T is a correction for the fact that the end of the cylinder is abrupt while the theory assume a smooth varying end.

Conclusion

- An increased diameter results in an increased instability causing an earlier oscillatory behaviour and a smaller excursion from the drop point.
- For drops under water the highest velocity is obtained in the beginning of the trajectory and is highest for cylinders with small diameter.
- A small difference shift in the COG results in a steady trajectory and a high impact velocity at the sea bottom.
- The simulated results have relatively good agreement with the experimental results dependent on the value of the effective trailing edge.