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Study of the Trajectory and Landing Points of Dropped Cylindrical Object with Different Longitudinal Center of Gravity

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Dropped objects are among the top ten causes of fatalities and serious injuries in the oil and gas industry (DORIS, 2016). Objects may accidentally fall down from platforms or vessels during lifting or any other offshore operation. The accurate prediction of the landing points of the dropped objects may protect underwater structures and equipment from being damaged. In this paper, the authors propose a three-dimensional (3D) theory to numerically simulate the dynamic motion of a dropped cylindrical object under the water and to investigate the influence of the longitudinal center of gravity (LCG) on the motion. A numerical tool called Dropped Objects Simulator (DROBS) has been further developed on the basis of this 3D theory. It is initially applied to a dropped cylinder with its center of gravity at the center of volume (cylinder #1, LCG = 0) falling from the surface through calm water. The calculated trajectories match very well with both the experimental and numerical results published in Aanesland (1987). Then DROBS is further utilized to simulate two dropped cylinders with positive LCG (cylinder #2) and negative LCG (cylinder #3), respectively. The simulated results from DROBS show better agreement with the measured data than the numerical results given in Chu et al. (2005). This comparison again validates and indicates the effectiveness of the DROBS program. Finally, the simulation is applied to investigate the effects of varying LCGs on the trajectory and landing points. The newly developed DROBS program can be used to simulate the distribution of the landing points of dropped cylindrical objects in order to predict risk-free zones for offshore operations.

INTRODUCTION

Dropping tools and equipment into the sea during a lifting operation or any other offshore operation is unfortunately a fairly common event. Table 1 states probabilities according to DNV (2010). *Dropped Objects Register of Incidents & Statistics* (DORIS, 2016) lists dropped objects as one of the top 10 causes for fatalities and serious injury in the oil and gas industry.

DNV (2010) proposed specific rules about the risk assessment of pipeline protection. In its recorded simplified method, the probability of object excursions on the seabed is assumed to be normally distributed. However, we still lack specialized techniques to predict the trajectory of dropped objects and the subsequent likelihood of striking additional structures and equipment as well as the consequences of such impacts (ABS, 2010). Therefore, the trajectory dynamics of objects falling into the water and their landing points is of interest for the protection of oil and gas production equipment resting on the seabed.

Aanesland (1987) experimentally and numerically investigated falling drill pipes. The results for the two series of model tests are presented. The first test series was performed in order to investigate the entire history of events, beginning with an object dropped from the platform deck and ending with the object landing on the seabed. The second drop test was intended to verify a computer program that was developed to calculate the motion, velocity, and acceleration of falling drilling pipes and to predict the impact load. This program solves a set of two-dimensional (2D) maneuvering equations that describe the motions of drill pipes.

Kim et al. (2002) focused on the study of the characteristic motions of 3D bodies freely falling through water. The time-domain six degrees-of-freedom motions of general 3D bodies dropping in water have been solved by a direct numerical simulation scheme. Viscous effects on the cylindrical bodies have been considered by the estimation of the drag coefficients of the

Type of lift	Frequency of the dropped object into the sea (per lift)
Ordinary lift to/from supply vessel with the platform crane < 20 tonnes	1.2×10^{-5}
Heavy lift to/from supply vessel with the platform crane > 20 tonnes	1.6×10^{-5}
Handling of load < 100 tonnes with the lifting system in the drilling derrick	2.2×10^{-5}
Handling of Blowout Preventer (BOP)/load < 100 tonnes with the lifting system in the drilling derrick	1.5×10^{-5}

Table 1 Frequencies for dropping objects into the sea (DNV, 2010)

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