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Probabilistic approach for collision risk analysis of powered vessel with offshore platforms

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ABSTRACT

The continuous increase in marine traffic and the construction of several offshore installations has led to a serious concern regarding the risks to offshore platforms from ship collisions. The main aim of this study was to carry out a probabilistic collision-risk analysis for offshore platforms exposed to powered collisions with passing vessels using an automatic identification system (AIS) database. The paper first describes the statistical distribution of the ship traffic under study and then considers how this information can be effectively used to estimate collision frequencies and impact energies for various categories of vessel, based on a simple probabilistic method. The effects of various collision mitigation measures, such as the use of enhanced collision alarming devices and the ability of platforms to rotate using thrusters, are considered in the frequency calculations. The risk method presented in this paper can be applied in the design and development phase of both new and existing platforms.

1. Introduction

Over time, the ocean has become busy with various types of vessels and offshore platforms. To meet the continuous increase in the demand for hydrocarbons, exploration and drilling have increased, several offshore structures have been constructed, and new ships and shipping routes have been introduced. Because marine transportation remains the cheapest way to transport cargo, there is increasing concern about collisions between vessels and offshore structures.

The risk of collision with offshore platforms is increased in areas of dense ship traffic, such as near coastal areas or naval bases. Effective planning of ship traffic is needed, along with more stringent rules and regulations for marine activities around platforms, from the planning and exploration stages to the operational stage of platform deployment.

The ships that collide with offshore platforms can be generally classified as visiting vessels or passing vessels (Vinnem, 2007; Moan et al., 2002). The vessels that visit platforms, such as supply boats, service vessels, and shuttle tankers that routinely berth at the offshore facilities, contribute significantly to collision accidents. Fig. 1 (a) shows the total loss of the Mumbai High North complex platform in July 2005 after a collision with a multipurpose support vessel, and Fig. 1 (b) shows the capsize of a monopod platform after a boat collision. Passing vessels may also pose a serious threat, especially if the offshore facility is located within a frequently sailed route (see Fig. 1 (c)) (Paik and Thayamballi, 2007). Fig. 1 (d) shows the distribution of the types of vessel involved in collision accidents according to the Worldwide Offshore Accident Databank (WOAD), obtained from OGP (2010). It shows that nearly 23% of the total collision accidents involved a passing vessel. A study of the United Kingdom continental shelf (UKCS) found that passing-vessel collisions occur an average of once every 2 years (Oil & Gas UK, 2010).

The estimation of collision risk requires the quantification of credible collision frequency and associated consequences, which is integral to the safe design and robust building of a platform (Bai and Wei-Liang, 2015). DNV (2002) classified risk assessment techniques into qualitative, semi-qualitative and quantitative techniques. Quantitative risk assessment (QRA) is considered to be the most sophisticated numerical technique that can provide useful guidance for predicting collision accidents, but it is associated with a large degree of uncertainty and requires expert judgement.

Based on the extent of damage to the structures, a collision event can be categorised as minor or major collision. A minor collision is characterised by only repairable damage of the structure and probably will not call for cease of operation. On the other hand, a major collision will damage the platform globally and most certainly require a cease of

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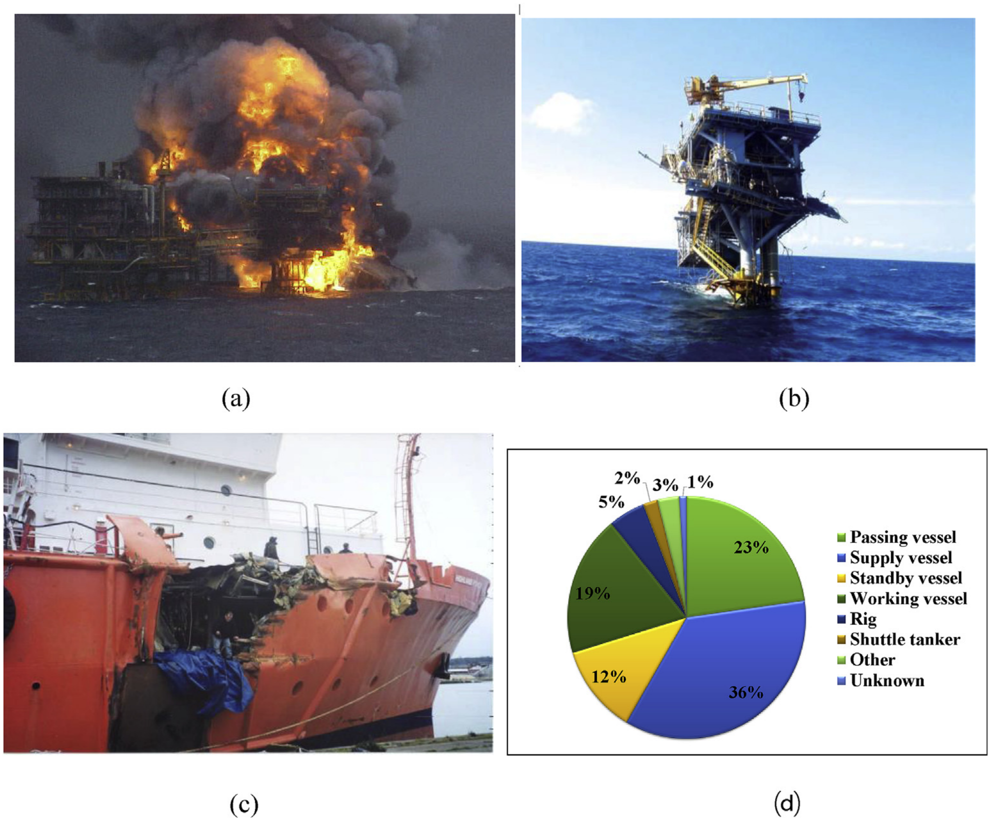

Fig. 1. Ship and offshore platform collision accidents (a) Mumbai High North complex platform accident arising from attendant vessel collision (Daley, 2013); (b) capsize of a monopod platform after a collision in Madura Island, Indonesia (Widjaja et al., 2013); (c) passing vessel *Marbella* after collision with an accommodation platform (MAIB, 2003) (d) accident statistics based on vessel type.

operation.

However, it seems extremely uneconomical to design a platform to withstand a major collision and remain operational. Therefore, in order to practically while at the same time economically solve the offshore collision problems the probability of major collisions should be kept at a low level by defining adequate preventive measure and minor ones should be considered in the design stage of the platform. This is the design concept of offshore structures against collision adopted by many classification societies.

Most studies on the estimation of collision frequency have taken a scenario-based approach, which uses historical accident databases such as WOAD (DNV.GL). Extensive accident reports and statistical analyses are recorded for the UKCS by the UK Health and Safety Executive (HSE) (see DNV 2007a, 2007b; Robson (2003)). Muncer (2003) analysed accident statistics for floating production storage and offloading (FPSO) and floating storage unit (FSU) structures from 1996 to 2002 and compared them with fixed installations in the UKCS area. The study revealed a 5% increase in the number of FPSO/FSU structures. The UK Offshore Operators Association (UKOOA) (2002) concluded that the collision probability for an FPSO subjected to passing traffic is increased due to the increased length of the FPSO, combined with a shuttle tanker, compared to fixed platforms. Furnes and Amdahl (1980) developed a drifting vessel collision-risk model for a shuttle tanker colliding with an offshore platform using Monte Carlo simulation techniques.

Ship traffic databases are also used for estimating passing-vessel collisions. Automatic identification systems (AIS) are considered to be the most advanced and efficient tools for tracking vessel movements, providing up-to-date information on location, heading, course and other details of the ship. Since 2002, IMO regulations have required new ships and all larger seagoing vessels (greater than 300 gross tons) and all passenger vessels to carry AIS on board (IMO, 2001). The AIS messages are transmitted from ship to ship and ship to port using very high frequency (VHF) radio wave signals in a limited geographical space (Eriksen et al., 2006). There are two methods by which AIS tracks ship movements: terrestrial and satellite. Terrestrial AIS is cheaper, but satellite AIS is more useful when a vessel is in open seas and out of range of the network of terrestrial AIS receivers.

Most studies have used AIS marine traffic information to study ship-ship collision probability. Several researchers have used AIS information to analyse safety and the risk of ship collisions in busy sea areas such as the Singapore Strait (Qu et al., 2011), the Gulf of Finland (Goerlandt and Kujala, 2011) and the Malacca Strait (Zaman et al., 2015). Xiao et al. (2015) analysed and compared AIS data for narrow and wide waterways. Zhang et al. (2016) proposed an advanced method to detect possible near-miss ship collisions using AIS data. All of these researchers studied ship-ship collisions; there have been very few studies of ship–platform collision frequency using AIS information (Haugen, 1998). Recently Hassel et al. (2017) used AIS data to study change in passing vessel traffic pattern found before and after platforms were installed and concluded that the current risk assessment practices are overly conservative.

Several commercial software programs are available for estimating collision risk, such as COLLIDE (Safetec), COLLRISK (Anatec UK Ltd.), Computerised Risk Assessment of Shipping Hazards (CRASH) (DNV), SOCRA (MARIN) and COLWT (GL). With the objective of harmonising various assumptions followed in the models, Safeship (2005) compared the models of MARIN, GL and DNV.

The existing software is based on model assumptions; however, improvements taking into account the advanced technologies now in use and the stricter rules and regulations have not been made. For instance, Hassel et al. (2014) highlighted improvements required in the collision-risk model, which was introduced about 20 years ago for the Norwegian continental shelf (NCS), and noted that the ability of the platform to physically get out of the way of a vessel on a collision course was not considered and that there was also inaccurate modelling of the failure factors considered for both the ship and offshore platform.

Geijerstam and Svensson (2008) also reviewed various risk models and concluded that ship watchkeeping failure is the main factor in collision risk. Flohberger (2010) concluded that passing-vessel accidents