Preliminary Tests on the Terminal Velocity of a Torpedo Anchor in Still Water

Davood Hasanloo, HuaKun Wang, Guoliang Yu
Department of Harbor, Waterway and Coastal Engineering, School of Naval Architecture, Ocean and Civil Engineering
Shanghai Jiao Tong University, Shanghai, China

ABSTRACT

Torpedo anchors, a cylindrical steel pipe with a conical tip, are used to moor deep-water offshore facilities. This kind of anchoring may be used in both drilling and production offshore activities. In this study, the terminal velocity of torpedo anchor and consequently its drag coefficient were measured in a water-filled tank with 4 m height and 40 cm in diameter. Four torpedo anchors made of steel were tested in thirty two experiments. A high speed video camera was installed close to the tank to record the falling process, and afterwards the desired frames were extracted and processed to measure the velocity of the anchor. The errors in image processing were calculated and reported, which were in an acceptable range. The results revealed that the mass and dimensions of the torpedo anchor had significant influence on the terminal velocity.

KEY WORDS: Torpedo anchors; moor; deep-water offshore facilities; terminal velocity; drag coefficient; image processing.

INTRODUCTION

Nowadays, the demand for fossil oil has grown greatly; as a result, the petroleum industry requires more drilling and production units even in water depths higher than 3000 m. The exploration and development of new facilities in such deep depths calls for more efficient and reliable anchoring system. However, the deepwater anchoring systems can be quite costly. This has pushed the oil and gas industry to always seek a simplified anchoring solution, which simplicity relates to effective installation which would reduce cost, time and complexity of operations.

The Deep Penetrating Anchor (DPA) or torpedo anchor is a new kind of anchoring system that has many advantages over conventional solutions. It consists of a cylindrical steel pipe with a conical tip which is used to moor deep-water offshore facilities. This kind of anchoring may be used in both drilling activities as it can be easily recovered, and in production offshore projects because it has enough holding power (Fernandes et al., 2006). To prepare it for installation, it has to be placed in a vertical position; hence, after it is launched, the momentum caused by its own weight can drive it to the soft seabed. That is why it is much less costly than the other conventional anchors. In order to gain sufficient kinetic energy and to reach a designated terminal velocity so that to penetrate into the desired burial depth, the torpedo anchor must be released from a high enough level above the seabed. Hence, the estimation of the torpedo anchor’s terminal velocity is of great importance. The installation of torpedo anchor does not need any external source of energy; it just needs one or two anchor-handling vessels and limited use of ROVs (remotely operated vehicles). Manufacturing is easy, and due to the compact size of this kind of anchors, compared to other anchors, transportation to the site will be more efficient. Its other advantages consist of precise horizontal positioning, applicability for taut leg mooring and low sensitivity to increasing water depth (Lieng, 1999).

Torpedo anchors have been comprehensively studied in laboratory and field tests. In 1969, 35 instrumented penetrator tests were conducted in soft saline clay deposits and empirical equations were proposed in order to predict the penetration depth into soft sediments, and documented in Young (1981). Chari et al. (1981) did some laboratory experiments on a standard 10 cm² static penetrometer on different soil targets. They also developed a new 45-cm² model and tested it in both field and laboratory. The development of the penetrometer and analysis of some of the results, i.e. tip and sleeve resistance measurements, were also presented in their paper. The installation of 26 dynamic penetrators in water depths ranging from 180 to 5500 m were summarized in Beard (1985). The tests were performed between 1976 and 1979 in sites on both coasts of the U.S., the Caribbean and the Atlantic. The Nuclear Energy Agency conducted a series of research studies into feasibility of high-level radioactive waste disposal in the oceanic sediments. In this effort, Freeman et al. (1984) proposed using a streamlined, free-falling projectile in order to achieve maximum possible penetration depth into the seabed. Levacher (1985) reported on the results of laboratory tests of a free-fall penetrometer equipped with an accelerometer for the determination of the in situ mechanical properties of reconstituted clays at varying moisture contents. The first commercial application of torpedo anchors was conducted in the Campos Basin, offshore Brazil (Medeiros, 2002). To achieve the best anchor design, model tests, with different weights and shapes, were made in laboratory. In accordance