2

CONCRETE FOR OFFSHORE STRUCTURES

2.1 INTRODUCTION

The utilisation of concrete in offshore construction started at the end of the 1960s to compete with steel used as a conventional structural material in this field. This innovation proved to be an effective and viable alternative to steel substructures due to its comparable structural and maintenance costs [8]-[9]. Furthermore, offshore structures made of concrete have proven to be extremely robust and also suitable for corrosion resistance. The utilisation of concrete in offshore structures goes back to the time of ancient Greeks and Romans, and traces of such structures still exist. Lambot, who built a boat in 1848 using sand-cement mortar over a frame of iron bars and wire, is acknowledged for the first-time use of reinforced concrete for constructing a floating vessel. Today, in a French museum, one of Lambot's boats remains. At the end of the 19th century, concrete started to be used as a hull (skeleton) building material for commercial vessels [10]. The primary usage of concrete at that time was commonly made worldwide and included concrete pontoons and barges. The Namsenfjord, designed in 1917 in Norway, was the first-ever reinforced concrete seagoing ship. Fougner then proceeded to construct many large reinforced concrete self-propelled boats. The first concrete production platform for petroleum and gas was built in 1950 in the Gulf of Mexico. More than 1000 functionally identical concrete structures have been constructed in this field since then [11]. The first concrete gravity-based structure (GBS) was constructed in US waters in 1978 [12]. In 1973 the first large North Sea Offshore concrete platform was mounted in the Ekofisk Tank in the Norwegian sector. In Brazil, three concrete caisson systems were designed in 1977 and 1978 for the South American offshore waters that were functionally identical to the Ekofisk tank [13]. Similar offshore concrete structures were designed over the past couple of years to be used in Germany, Netherlands, Australia, Nigeria, Russia, Philippines, Italy, and Canada. Moreover, large offshore and inshore floating concrete structures exist in Japan, Indonesia and Congo.

Concrete structures that are exposed to an open-sea environment are commonly said to be offshore concrete structures [14]. In the offshore oil industry, offshore concrete platforms are primarily used as drilling units to produce or store oil or natural gas. These also include machinery and equipment required for oil and gas exploration and/or extraction but may also have other specialised applications, particularly in deep water, such as LNG offshore terminals or offshore wind support turbines.

2.2 TYPES OF OFFSHORE CONCRETE STRUCTURES

Concrete has now become the most commonly used man-made construction material in the world with its commonality and comparatively low cost, and still being chosen for civil engineering and infrastructure construction in the marine environment [15]. Many offshore structures have also been established, including civil and military terminals, offshore airports, offshore wind turbines, sea lighthouses, radar stations, island reefs, and fortifications [16]. These are built to either remain semi-permanently or permanently fixed to the seabed by applying suitable techniques such as piles and anchors due to gravity or to remain firmly floating and fastened.

In general, offshore, inshore, and onshore structures can be either bottom-based or floating. Several bottom-founded structures are needed to float at different phases of their lifetime. The following explanation of different types of platforms is very short but is intended to give the reader a sense of the tremendous flexibility that can be realised with concrete.

2.2.1 Bottom-founded Structures

These structures can be classified into gravity-based, concrete cylinder pile-supported, and floatable/bottom-founded concrete-hull structures. Bridge piers, seabed walls, river navigations, dams and marine caissons are types of bottom-founded concrete structures that are manufactured elsewhere and allowed to be floated before installation. These precast structures typically consist of thin-shell floating structures with internal ballasts. Such structures provide considerable benefits in terms of cost, construction time, risk reduction and utilization of the facility with minimising environmental damage.

2.2.1.1 Gravity-based/Fixed Structure

Because of its very large weight, the gravity-based structure (GBS) (Figure 2.1) retains its location on the seabed. It is a type of base suitable for soils with high bearing capacity, also known as gravity-based foundations (GBF) [17]. The gravity-based structure (GBS) is a massive foundation constructed on the seabed to serve as a base for offshore structures. These structures can be relatively compact, such as a wind turbine, or quite extensive, such as an integrated oil drilling and production platform (topsides), which generally includes oil-storage caissons. For the latter case, a GBS typically consists of a concrete caisson with multiple shafts (Figure 2.1) [18]. Several GBSs' often require buoyancy for easy removal