International Journal of Computational and Experimental Science and ENgineering
(IJCESEN)
Vol. 10-No.4 (2024) pp. 1673-1677
http://www.ijcesen.com

ISSN: 2149-9144

Research Article

Offshore Structures

Serap Özhan Doğan[1*], Burak Galip Anık[2], Şükrü Eren[3]

[1] İstanbul Beykent University, Faculty of Engineering and Architecture, Department of Mechanical Engineering-Turkiye
* **Corresponding Author Email:** serapdogan@beykent.edu.tr - **ORCID:** 0000-001-5210-1549

[2] Tersan Shipyard R&D Department Yalova-Turkiye
Email: banik@tersan.com.tr - **ORCID:** 0009-0006-9063-8594

[3] Tersan Shipyard R&D Department İstanbul-Turkiye
Email: sukrue@tersan.com.tr - **ORCID:** 0000-0002-0926-557X

Article Info:

DOI: 10.22399/ijcesen.794
Received : 19 December 2024
Accepted : 24 December 2024

Keywords :

Fixed Offshore Platform,
Oil and Gas Platforms,
Newbuilding,
Offshore power stations,
Strength and design.

Abstract:

Globalization has become the main element of business life today and leads to increased competition. The main factors affecting competition in the oil and gas industry are oil/ natural gas prices and demand, exploration and production costs, global production levels, alternative fuels, and government (including environmental) regulations. This scope of work, It deals with the characteristics, design and manufacturing parameters of the fixed offshore platform and the types of platforms used to drill and produce oil/ natural gas under the sea. Especially the formation stages of fixed offshore platform projects are mentioned. Various analyzes need to be made in the process from the decision taken in the construction of the fixed offshore platform, from its design to the manufacturing phase and the time of installation. As in offshore designs, these analyzes should be aimed for other platform structures to build an economical and reliable structure.

1. Introduction

Globalization has become a fundamental element of business life in the last few years. In addition, it is believed that there is a need to focus on globalization processes. It is seen that capital knows no borders, knowledge has become the biggest capital, businesses are opened to international markets, and technology is easily transferred. These and similar effects have led to changes in the business world, as well as forcing businesses that want to succeed in the new business world to change. The effect of this change has also brought increased competition. Today, global energy policies are mainly determined by oil and natural gas. Key factors affecting competition in the oil and gas industry are oil/natural gas prices and demand, exploration and production costs, global production levels, alternative fuels and government policies.

Due to the high demand for oil and natural gas, more exploration and production activities are carried out [1]. For this exploration and production, different types of constructions are used as offshore oil/natural gas fields, offshore towers and platforms depending on water depth and water condition. Rigs are used to drill wells and platforms are set up for oil/natural gas extraction at the site. Different challenges arise when drilling on land. When drilling in the sea, it is difficult because the sea floor can sometimes be thousands of feet below sea level. Therefore, an artificial drilling platform should be constructed in the sea, while ground drilling provides a platform for drilling. With the establishment of the first platform in the Gulf of Mexico for oil exploration in the late 1940s, a new field of expertise began [2]. Turkey has long coastlines in terms of location and sea-oriented studies are becoming widespread day by day. These types of platforms are divided into mobile and fixed. Figure 1 shows an image of some offshore drilling platforms.

2. Types of marine drilling platforms

2.1 Tower Platforms (Compliant Towers)

It is very similar to stationary platforms. It is attached to a foundation on the seafloor and a narrow tower that extends to the platform. This tower has a more flexible structure as opposed

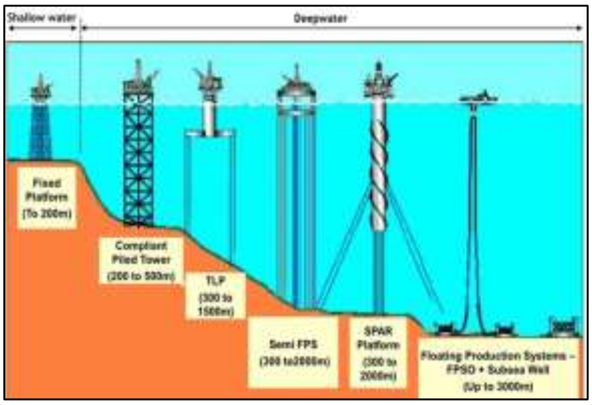

Figure 1. *Platform Types [3]*

to the rigid legs of a fixed platform. This flexibility allows it to operate in much deeper water as it can absorb most of the pressure exerted on it by wind and sea. Despite its flexibility, it is strong enough to withstand hurricane conditions.

2.2. Tension Leg Platforms

It connects to the seafloor with its long flexible legs and extends to the platform. These legs allow very little vertical movement. Tensioner platforms can operate to a depth of 7000 fit.

An offshore oil drill with a floating drilling unit containing columns and barges that will cause the barges to submerge to a predetermined depth if filled with water. It is the most common type of offshore drilling rig.

The rig is located in the partially submerged section. During drilling, the water-filled underbody provides stability to the rig. Semi-submersible rigs are usually anchored by large anchors weighing more than ten tons each.

Combined with the submerged part of the rig, these anchors ensure the platform is stable and secure enough for use in turbulent offshore waters. For semi-submersible rigs, it can be held in place using dynamic positioning. In this type of rig platform, a hole is drilled in the seafloor and can be quickly transported to new locations.

2.3. Floating Production System

In addition to semi-drilling rig structures, there are oil production equipment and drilling equipment on them. Ships can also be used as floating production systems.

The platforms are held in place by large heavy anchors or the dynamic positioning system used by drill vessels. After drilling is complete, a floating production system is actually attached to the seafloor instead of the wellhead platform. Oil and natural gas extracted by risers are transported from the wellhead to the production facilities on the semi-submersible platform. These generation systems can operate at water depths of 6000 fit.

2.4. Spar Platforms

It is among the largest offshore platforms in use. These gigantic platforms consist of a large cylinder supporting a typical fixed rig platform. These cylinders do not extend to the seafloor. Instead, it is connected to the base by a series of cables and lines. The large cylinder serves to stabilize the platform in the water and allows the movement to absorb the force of potential hurricanes.

2.5. Drillships

They are vessels designed for drilling operations. These vessels are specially designed to transport drilling platforms to deep sea locations. A typical drill ship has all the equipment normally found on a large ocean liner. It has a drilling platform and embankment located in the middle of its deck. In addition, drillships have a hole (called a "moon pool") that runs down the inside of the hull, allowing the drill string to extend from the hull into the water. This offshore oil rig is capable of drilling in very deep waters. Drillships use 'dynamic positioning systems. Drillships are equipped with electric motors on the underside of the ship's hull that can move the ship in all directions. These engines ensure that the ship is always directly above the drilling site. For this, it is integrated into the ship's computer system using satellite positioning technology, together with the sensors in the drilling template.

2.6. Fixed Platform

It is one of the marine drilling platform types. Offshore platforms are massive steel or concrete structures used for the exploration and extraction of oil and gas from the earth's crust. Offshore structures are offshore, lakes, bays, etc., miles away from shorelines are established in places. This study covers the investigation of fixed offshore platform type.

3. Design analysis and manufacturing parameters of offshore fixed platforms

Offshore platforms have many uses such as oil exploration and production, navigation, ship loading, unloading, supporting bridges and crossings. Offshore oil production is one of the most visible of these applications and presents a significant challenge for the design engineers. These offshore structures must have a design life of twenty-five years or longer (in very harsh sea conditions) and perform their functions safely. The most important aspects in their design is the peak loads created by hurricane winds and waves are the fatigue loads created by the waves during the life of the platform and the movement of the platform.

Platforms can sometimes be exposed to strong currents that load the mooring system and cause eddy shedding [4]. In figure 2, a picture of the offshore platform is shared.

Figure 2. *Offshore platforms*

Offshore structures can be made of steel, reinforced concrete, or a combination of both. Offshore oil and gas platforms are often made of various grades of steel, from mild steel to high-strength steel. However, some old buildings were made of reinforced concrete. While the legs of the platform are made of concrete or steel, they extend down from the platform and are fixed to the seafloor with stakes. In some concrete structures, the weight of the legs and seafloor platform is so great that they do not need to be physically attached to the seafloor. Instead, they must stand on their own mass. There are many possible designs for these fixed permanent platforms. The main advantages of such platforms are their robustness. Since they are attached to the sea floor, they have limited movement due to wind and water forces. These platforms cannot be used in extremely deep waters and it is not economical to build such long legs. Offshore platforms are very heavy and are among the tallest man-made structures in the world. Oil and natural gas are separated on the platform and transported to shore by pipelines or tankers.

While starting these huge projects, various conditions are expected to meet. Basically, offshore platform construction projects need to go through the following stages.

- Making the feasibility study of the place to be invested,
- Investigation of diving inspections of the places to be installed,
- Making conceptual, basic and detailed designs of the platform,
- Making strength calculations of the elements of the platform,
- Obtaining design approval from necessary places,
- Procurement of necessary materials for construction,
- Starting to manufacture the steel structures of the platform,
- Preparation of shipping and offshore installation procedures for the elements of the platform,
- Loading, transporting and installing the platform and its elements,
- Assignment of necessary persons and units.

Each region of the world has its own unique topographic, geographical and physical characteristics. For this reason, the location of the area and some of its features should be considered within the framework of general planning principles in site selection for platforms. These are climatic features of the region, geological features, geomorphological features, seismicity, tsunami hazard, status of underground water resources, ecological characteristics of potential areas, nature protection zones, economic factors, water depth, spatial suitability, political reasons [5]. The platform is highly exposed to loads created by environmental conditions. These are wind, current, earthquake and wave. The most important of these environmental loads is the effect of waves and earthquakes on the platform. Wind load often has a significant impact on platform installation and maintenance. The current force, on the other hand, has very little effect when compared to other forces [6]. Our country is located in a risky geological area in terms of earthquake zones. In this respect, it is necessary to ensure the reliability of the structures by making earthquake calculations. The bearing capacity calculations of the piles should also be made. In fixed platforms, steel, concrete and composite materials are most commonly used for the feet connecting the platform to the seabed [7].

Another important part of the design of offshore structures is the investigation of the ground. Soil surveys should also be determined depending on the characteristics of the project and the geological conditions of the site. These investigations may include many studies such as relevant in situ soil drilling and laboratory tests (loading tests, observation pits, seismic tests). It is important to plan in such a way that sufficient information about the ground can be obtained and the ground conditions can be modeled with sufficient accuracy [5]. In the event of a storm, the condition of the seabed is of great importance. While creating fixed offshore platform systems; soil conditions, load conditions, water depths and seismicity of the region, pile bearing capacity calculations should also be taken into account [8]. Also, depending on the floor, the design of the platform legs will vary greatly. Geotechnical properties are examined as damage types such as collapse and settlement may occur depending on the changes in bearing capacity [9].

While determining the structural features of the platforms, one of the most important factors in being economical and applicable is the water depth. The type of open sea structure is determined according to the water depth and other parameters.
Considering the environmental and other parameters of the platform, there are different main analyzes required for the platform design and installation, which are considered [10]. The required analyzes for offshore platforms are presented in table 1. An evening image of the Fixed Offshore Platform is shared in figure 3.

***Table 1**. Analysis for Fixed Offshore Platform*

Types of analysis	
1) On-Site Analysis	8) Earthquake Analysis
2) Impact Analysis	9) Transient Analysis
3) Transport Analysis	10) Easement Analysis
4) Evolving Analysis	11) Straightening Analysis
5) Installation Analysis.	12) Fatigue Analysis
6) Loading Analysis	13) Lift / Take Off Analysis
7) Ribless Stability Analysis	14) Pile and Conductor Pipe Driveability Analysis

***Figure 3.** Fixed Offshore Platform View*

Risers, overhead equipment, flow arms, bulk manifold, piping, vent boom, vents and drains, escape routes, fire protection and lifesaving equipment, deck structures, main deck, mezzanine deck, cellar and lower cellar deck levels, pig launcher Pipelines up to risers, including 3D elbows, top ports, clamps, J pipes, instruments, level gauges, pressure and temperature gauges, cable ducts, etc. are used in fixed offshore platforms. They are designed and manufactured to cover high-level facilities, including stairs.

4. Conclusion and recommendations

Today, oil and natural gas are the needs of human beings. For this reason, such studies should be a priority for oil/natural gas exploration and production.
In Turkey, the production and use of a fixed offshore platform is a step in the development of more advanced technologies.
The formation process of these offshore structures is quite complex and needs to include various analyses. One of the most important elements is that a good feasibility study should be done for the place where the fixed open platforms will be installed.
As a result, offshore platforms vary according to their installation location and must meet various conditions for this installation. If the conditions are met, one of the most difficult parts of the design and manufacturing phase should be passed. Due to the advantage of being surrounded by seas on 3 sides of Turkey, marine technologies are of great importance in order to stay in global competition. In Turkey, there are places with sufficient capacity where such large constructions can be made. Such structures can easily be built in shipyards. Oil and Gas platform is studied in the literature [11-18].

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
- **Acknowledgement:** The authors declare that they have nobody or no-company to acknowledge.
- **Author contributions:** The authors declare that they have equal right on this paper.
- **Funding information:** The authors declare that there is no funding to be acknowledged.
- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

References

[1]A.Abdul Kadir S. Sarip, N. H. Nik Mahmood S., Mohd Yusof M. Z. , Hassan M. Y., Md. Daud and S. Abdul Aziz, (2015), A Review of Integrated Management System in the Offshore Oil and Gas Industry, *Journal of Advanced Review on Scientific Research*, 12(1);11-25.

[2]Yüksel A., Çevik, E., Çelikoğlu Y., (1998), Kıyı ve Liman Mühendisliği, İnşaat Mühendisleri Odası Ankara Şubesi, Ankara.

[3]https://gamaoilgas.weebly.com/studying-center/sub-sea-facilities

[4]Sadeghi K., (2007), An Overview of Design, Analysis, Construction and Installation of Offshore Petroleum Platforms Suitable for Cyprus Oil/Gas Fields, *GAU J. Soc. & Appl. Sci*., 2(4), 1-16.

[5]Cesur B., Gül, A., Ay Z., (2018), Kıyı Kullanımların Yüzen Platform Üzeri Çok Amaçlı Kent Parkı Tasarım Yaklaşımı, *9.Kıyı Sempozyumu*. P.400

[6]Karadeniz H., (1983), Spectral Analysis and Stochastic Fatigue Reliability Calculation of Offshore Steel Structures, Report on Offshore Structurel Analysis, *Department of Civil Engineering, Delft University of Technology*.

[7]Topçuoğlu A., (2006),Yat Limanlarında İnşaat Tekniklerinin Karşılaştırılması, *Dokuz Eylül Üniversitesi, Fen Bilimleri Enstitüsü, YL Tezi, Aralık, İzmir.*

[8]Öncü, Z.İ., (2010), Betonarme İskelelerin Bakım, Onarım ve Güçlendirilmesi, *Dokuz Eylül Üniversitesi, Fen Bilimleri Enstitüsü, Deniz Bilimleri ve Teknolojisi Enstitüsü, Kıyı Mühendisliği Programı, YL Tezi, Mart, İzmir.*

[9]AYGM, (2016), T.C. Ulaştırma, Denizcilik ve Haberleşme Bakanlığı Altyapı Yatırımları Genel Müdürlüğü, *Kıyı Yapıları Planlama ve Tasarım Teknik Esasları*.

[10]Sadeghi K,(2001), Coasts Ports and Offshore Structures Engineering. *Power and Water University of Technology*, Tehran, Iran, p 50.

[11]CAO, N., LI, H., & LIU, M. (2018). Effect of Stress Sensitivity on Production of Tight Heterogeneous Reservoir. *International Journal of Computational and Experimental Science and Engineering*, 4(3), 30–33. Retrieved from https://ijcesen.com/index.php/ijcesen/article/view/73

[12]DURMAZ, U., & YALÇINKAYA, O. (2019). Comparing the Effect of Process Fluid for Wet Ground Heat Exchanger. *International Journal of Computational and Experimental Science and Engineering*, 5(3), 147–150. Retrieved from https://ijcesen.com/index.php/ijcesen/article/view/105

[13]EBOJOH, E., & AKPOBİ , E. D. (2020). Computer Aided Pressure Transient Analysis of a Layered Reservoir System with a Constant Pressure Boundary. *International Journal of Computational and Experimental Science and Engineering*, 6(1), 35–41. Retrieved from https://ijcesen.com/index.php/ijcesen/article/view/113

[14]SUN, J., LI , Q., CHEN , M., & ZHANG , Z. (2019). The Key Factor Analysis to the Reservoirs on the Basis of Bayesian Law. International Journal of Computational and Experimental Science and Engineering, 5(1), 37–42. Retrieved from https://ijcesen.com/index.php/ijcesen/article/view/83

[15]Sadigova, G., & Zamanova, A. (2024). Gravity Field Numerical Analysis and Depth Structure of the South-Eastren Caucasus. *International Journal of Computational and Experimental Science and Engineering*, 10(1);11-14. https://doi.org/10.22399/ijcesen.6

[16]Sadigova, G., Zamanova, A., & Hasanov, A. (2024). Complex analysis of the geodynamic conditions of the Absheron-Balkhan oil and gas zone. *International Journal of Computational and Experimental Science and Engineering*, 10(1);1-5. https://doi.org/10.22399/ijcesen.7

[17]ZHAO, W., LIU, H., LU, C., WANG , J., MENG, L., & ZHONG, R. (2019). Experimental Investigation of CSS Assisted by Gas-viscosity Reducer Co-Injection with Different Types of Wells and Heavy Oil. *International Journal of Computational and Experimental Science and Engineering*, 5(1), 1–9. Retrieved from https://ijcesen.com/index.php/ijcesen/article/view/77

[18]LİANG, X., HU, J., ZHOU, Q., DU, L., Lİ, Q., Lİ, B., & CHENG, Y. (2020). Shale Gas Technical Development and Innovation. *International Journal of Computational and Experimental Science and Engineering*, 6(2), 92–97. Retrieved from https://ijcesen.com/index.php/ijcesen/article/view/120