



OFFSHORE STRUCTURES DESIGN, CONSTRUCTION AND MAINTENANCE

Mohamed A. El-Reedy, Ph.D.



Offshore Structures

Design, Construction and Maintenance

Mohamed A. El-Reedy, Ph.D.
Consultant Engineer



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Offshore Structures

Design, Construction and Maintenance

*This book is dedicated to the spirits of my mother and my father, and to
my wife and my children Maey, Hisham and Mayar.*

Preface

When a structural engineer starts work on offshore structure design, construction or maintenance, the offshore structure may appear to be a black box to him. Most engineering faculties, especially those in structural or civil engineering, focus on the design of residential, administrative, hospital and other domestic buildings from concrete or steel, while other faculty focus on harbor design.

The design of offshore structure platforms is a combination of steel structure design methods and loads applied in harbors, such as waves, current and other parameters. On the other hand, offshore platform design depends on technical practice, which depends on the experience of the engineering company itself.

While the construction of steel structures is familiar to the structural engineer, as anyone can observe construction of a new steel building, the construction and installation of an offshore structure platform are very rarely seen unless one has a direct role in the project, especially because the installation will be in the sea or ocean. There are far fewer offshore structures world-wide than there are steel structures for normal buildings on land, and the major design guidance for offshore structures lies in research and development, which is growing very fast to keep pace with development in the global oil and gas business. Therefore, all the major oil and gas exploration and production companies support and sponsor research to enhance the design and reliability of offshore structures, in order to improve revenues from their petroleum projects and their assets.

This book aims to cover the design, construction and maintenance of offshore platforms in detail, with comprehensive focus on the critical issues in design that the designer usually faces. The book also provides the simplest design tools, based on the most popular codes (such as API and ISO) and the other technical standards and practices that are usually used in offshore structure design. In addition, it is important to focus on methods for controlling and reviewing the design that most engineers will face in the review cycle, so this book covers the whole range of the offshore structure engineer's activities.

Corrosion of offshore structure platforms costs a lot of money to control and to maintain within the allowance limit so that it will not affect the structure's integrity, so methods for designing and selecting a suitable cathodic protection system and the advanced methods of protecting the structure from corrosion are very important to the structural engineer, and they are considered in depth in this text.

An offshore structure platform is a considerable asset in the oil and gas industry, so another goal of this book is to assist the structural engineer in making decisions in design that take into consideration the factors, parameters and

constraints faced by the owner that control the options and alternatives in the engineering studies phase.

Furthermore, it is very important to the owner, engineering firm and contractor that the offshore project's lifespan be identified. In other words, the structural engineer should have an overview of the relation between the structure's system and its configuration from both an economic and an engineering point of view.

Most offshore structure platforms were constructed world-wide in the period of growing oil investment between 1970 and 1980, so these platforms now are over 40 years old. Consequently, a lot of mature offshore structures are going through rehabilitation designed to increase and maintain their structural reliability. Development of the integrity management system with up-to-date and advanced techniques for qualitative and quantitative risk assessment has been essential to the risk-based inspection and maintenance planning that enhance the reliability of platforms during their lifespan. Accordingly, this book provides advanced techniques for topside and underwater inspection and assessment of offshore structure platforms, as well as ways to implement the maintenance and rehabilitation plan for the platform that match business requirements.

It is also important to present case studies of repair and strengthening of platforms and the methods of decommissioning platforms when required.

This book is intended to be a guidebook for junior and senior engineers who work in design, construction, repair and maintenance of fixed offshore structure platforms.

The text serves as an overview of, and a practical guide to, traditional and advanced techniques in design, construction, installation, inspection and rehabilitation of fixed offshore structure platforms, along with the principles of repairing and strengthening the structures and the methodology for delivering a maintenance plan for the fleet of platforms.

*Mohamed Abdallah El-Reedy
elreedyma@gmail.com
Cairo, Egypt*

The Author



Mohamed A. El-Reedy's background is in structural engineering. His main area of research is the reliability of concrete and steel structures. He has provided consulting to different engineering companies and oil and gas industries in Egypt and to international companies, such as the International Egyptian Oil Company (IEOC) and British Petroleum (BP). Moreover, he provides different concrete and steel structure design packages for residential buildings, warehouses, and telecommunication towers and electrical projects with WorleyParsons Egypt. He has participated in Liquefied Natural Gas (LNG) and Natural Gas Liquid (NGL) projects with international engineering firms. Currently, Dr. El-Reedy is responsible for reliability, inspection, and

maintenance strategy for onshore concrete structures and offshore steel structure platforms. He has performed these tasks for hundreds of structures in the Gulf of Suez in the Red Sea.

Dr. El-Reedy has consulted with and trained executives at many organizations, including the Arabian American Oil Company (ARAMCO), BP, Apachi, Abu Dhabi Marine Operating Company (ADMA), the Abu Dhabi National Oil Company, King Saud's Interior Ministry, Qatar Telecom, the Egyptian General Petroleum Corporation, Saudi Arabia Basic Industries Corporation (SABIC), the Kuwait Petroleum Corporation, and Qatar Petrochemical Company (QAPCO). He has taught technical courses about repair and maintenance for reinforced concrete structures and about advanced materials in the concrete industry world-wide, especially in the Middle East.

Dr. El-Reedy has written numerous publications and has presented many papers at local and international conferences sponsored by the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Concrete Institute, the American Society for Testing and Materials, and the American Petroleum Institute. He has published many research papers in international

technical journals and has authored four books about total quality management, quality management and quality assurance, economic management for engineering projects, and repair and protection of reinforced concrete structures. He received his bachelor's degree from Cairo University in 1990, his master's degree in 1995, and his Ph.D. from Cairo University in 2000.

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Introduction to Offshore Structures

1.1 INTRODUCTION

Offshore structures have special economic and technical characteristics. Economically, offshore structures are dependent on oil and gas production, which is directly related to global investment, which is in turn affected by the price of oil. For example, in 2008 oil prices increased worldwide, and as a result many offshore structure projects were started during that time period.

Technically, offshore structure platform design and construction are a hybrid of steel structure design and harbor design and construction.

Only a limited number of faculty of engineering focus on offshore structural engineering, including the design of fixed offshore platforms, floating or other types, and, perhaps due to the limited number of offshore structural projects in comparison to the number of normal steel structural projects, such as residential facilities and factories. In addition, offshore steel structure construction depends on continuous research and study drawn from around the world.

All the major multinational companies that work in the oil and gas business are interested in offshore structures. These companies provide continuous support for research and development that will enhance the ability of their engineering firms and construction contractors to support their business needs.

1.2 HISTORY OF OFFSHORE STRUCTURES

As early as 1909–1910, wells were being drilled in Louisiana. Wooden derricks were erected on hastily built wooden platforms that had been constructed on top of timber piles.

Over the past 40 years, two major types of fixed platforms have been developed: the steel template, which was pioneered in the Gulf of Mexico (GoM), and the concrete gravity type, first developed in the North Sea. Recently, a third type, the tension-leg platform, has been used to drill wells and develop gas projects in deep water. In 1976, Exxon installed a platform in the Santa Barbara, CA, channel at a water depth of 259 m (850 ft). Approximately two decades earlier, around 1950, while the developments were taking place in the GoM and Santa Barbara channel, the BP (British Petroleum) company