IN-LB	Inch-Pound Units
SI	International System of Units

Design and Construction of Fixed Offshore Concrete Structures—Guide

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This document is a guide for the design and construction of fixed reinforced and prestressed concrete structures for service in a marine environment. Only fixed structures that are founded on the seabed are covered.

Contents include materials and durability; dead, deformation, live, environmental, and accidental loads; design and analysis; foundations; construction and installation; and inspection and repair. The two appendixes discuss environmental loads such as wave, wind, and ice loads in detail, and the design of offshore concrete structures for earthquake resistance.

Keywords: concrete construction; cracking; dynamic loads; earthquakes; earthquake-resistant structures; floating; foundations; gravity-based structure(s); grouting; harbor structures; ice; inspection; marine; offshore structures; platform; post-tensioning; prestressed concrete; slipforming; underwater construction; waves.

CONTENTS

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CHAPTER 1—GENERAL

1.1—Introduction

Concrete structures have been constructed and used all over the world, including for fixed offshore structures. As concrete and construction technology continues to advance, fixed concrete structures are increasingly being used in areas with relatively shallow water depths and/or regions subjected to extreme waves and ice/iceberg impact loads. This guide summarizes considerations for the design and construction of fixed offshore concrete structures. Widianto et al. (2016, 2019) described distinctive characteristics of offshore concrete gravity-based structures (GBSs) compared to typical buildings and bridges.

Where adequate data are available, specific recommendations are made, whereas in less developed areas, particular points are indicated for consideration by the designer. The design of offshore structures requires much creativity from the designer, and it is intended that this guide encourage creativity and continuing research advancements in the development of structures that are safe, serviceable, and economical. Widianto et al. (2018) presents innovative design and effective execution method in one of the recent offshore structures supported by concrete GBS.

1.2—Scope

This guide is intended to be used for the design of fixed concrete structures for service in a marine environment.

This includes reinforced, prestressed, and post-tensioned concrete structures. Only fixed structures that have their foundations on the seabed and achieve their stability from the vertical forces of gravity are covered herein. Applications include fixed offshore gravity structures for the oil and gas industry, and wind turbine bases. This guide addresses the materials, analysis, and design, including temporary configurations during construction, installation, and relocation while floating, using the structure's positive buoyancy, foundations, inspection, and repair aspects. This guide is not intended to cover maritime structures such as jetties or breakwaters, bridges and associated foundations, tunnels, berthing structures (pile-supported platforms, bulkheads), or those that are constructed primarily as ships or boats. Waterfront and coastal concrete marine structures are covered in ACI PRC-357.3. Floating and float-in concrete structures are covered in ACI PRC-357.2.

ACI CODE-318, along with several other ACI documents, should be used in conjunction with this guide. Because of the severe nature of the marine environment and unique loading conditions, certain recommendations herein supplement, complement, or supersede the requirements of ACI CODE-318. Emphasis is placed on special considerations for the design, construction, and material specifications for concrete fixed offshore gravity structures. Within the international community, there are several codes, standards, and guidelines addressing various aspects of the design of fixed offshore gravity structures. References have been made to these documents and other publications as well to guide the user through the unique requirements for the design of fixed offshore gravity structures.

1.3—Instrumentation

In regions of the structure or foundation where it is necessary to actively control conditions to ensure an adequate margin of safety for the structure, adequate instrumentation should be provided to monitor the conditions. Such conditions might be fluid level, temperature, soil pore water pressure, seismic accelerations, or extent of scour around the foundation. In addition, during installation, adequate instrumentation should be used to verify that installation tolerances are met.

When new concepts and procedures that extend the frontier of engineering knowledge are used, instrumentation should be provided to enable measured behavior to be compared with predicted behavior.

1.4—Auxiliary systems and interfaces

Special consideration should be given to planning and designing auxiliary nonstructural systems and their interfaces with a concrete structure.

Auxiliary mechanical, electrical, hydraulic, and control systems have functional requirements that may have a significant impact on structural design. Special auxiliary systems may be required for different design phases of an installation, including construction, transportation, installation, operation, and relocation.

Unique operating characteristics of auxiliary systems should be considered in assessing structural load conditions. Suitable provisions should be made for embedments and penetrations to accommodate auxiliary equipment.

CHAPTER 2—NOTATION AND DEFINITIONS

2.1—Notation

A = accidental load, lb
A_s = area of reinforcing steel, in.^{2}
b = cross-sectional width, in.
C_m = inertial coefficient
c = cover of reinforcement, in.
D = deformation load, lb
D_o = member's diameter, in.
d_b = diameter of reinforcing bar, in.
d_e = effective tension zone, in.
E = environmental load, lb
E_e = extreme environmental load, lb
E_o = frequently occurring environmental load (typically owner-defined), lb
E_s = reinforcing steel modulus of elasticity, psi
f_c' = 28-day strength of concrete, psi
f_s = stress in reinforcing bar, psi
f_t = mean tensile strength of concrete, psi
f_y = yield stress of reinforcing bars, psi
G = permanent loads that do not vary in magnitude, position, or direction during the period considered, lb
G_1 = permanent load due to the self-weight of the structure, lb
G_2 = permanent load due to the weight of permanent ballast, permanently installed mechanical outfitting, and external hydrostatic pressure up to the mean water line, lb
h = section thickness, in.
Q = variable loads that originate from normal operations of the structure and vary in magnitude, position, and direction during the period considered, lb
Q_1 = variable load due to live load, stored materials, fluids, fluid pressure, and variable ballast, lb
Q_2 = variable load due to short duration forces from operation, lb
w_d = limiting nominal characteristic crack width, in.
x = depth of compression zone prior to cracking, in.
γ_L = load factor
γ_m = material factor
Δ_{ps} = increase in tensile stress in prestressing steel with reference to the stress at zero strain in the concrete, psi
λ = wave length

2.2—Definitions

ACI provides a comprehensive list of definitions through an online resource, ACI Concrete Terminology. Definitions provided here complement that source.

adfreeze—the process by which two objects adhere to each other through ice formation.