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Report on Floating and Float-In Concrete Structures

Reported by ACI Committee 357

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This report addresses the practical experience and engineering considerations for the design and construction of floating concrete structures. Recommendations for design loads and design criteria are presented. Design procedures and methods of analysis are discussed to better acquaint the reader with the design considerations unique to floating marine structures. Methods used to construct floating concrete structures play a major role in the success of each application. Construction methods and materials used for recent applications are presented to demonstrate the importance of the construction process during the planning and design of marine concrete structures. Important aspects of delivery, from the construction site and installation at the deployment site, are presented. The durability and serviceability of floating structures at remote sites are important considerations to project planners and developers. Construction execution, materials selection and inspection, maintenance, and repair techniques are discussed. The materials, processes, quality control measures, and inspections described in this document should be tested, monitored, or performed as applicable only by individuals holding the appropriate ACI Certifications or equivalent.

Keywords: abrasion; accidents; admixtures; aggregates; concrete construction; concrete durability; detailing; dynamic loads; fatigue (materials); finite element method; floating structures; inspection; installing; lightweight concretes; limit design method; loads forces; maintenance moorings; permeability; post-tensioning; precast concrete; prestressed concrete; prestressing steels; quality control; reinforced concrete; reinforcing steels; repairs; serviceability; ships, stability; structural design surveys; towing.

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ACI 357.2R-10 supersedes ACI 357.2R-88 and was adopted and published July 2010.

CHAPTER 1—INTRODUCTION AND SCOPE

1.1—Introduction

Prestressed or reinforced concrete structures are used as either permanently floating structures or temporary float-in structures to facilitate marine construction. In this report, the definition of a floating structure is a structure that is temporarily, intermittently, or continuously afloat. For those floating structures that have a bow or stern, the bow or stern may be raked or shaped as required. Certain floating structures included within this definition are designed for towing and subsequent grounding, and afterward function as fixed structures. Later, these structures may be refloated and transported to a new location. Other structures are designed to remain continuously afloat, with or without permanent mooring.

Permanently floating structures serve a variety of uses such as industrial plantships, floating bridges, floating dry docks, offshore terminals, navigation structures, and parking and hotel structures. Applications of temporary float-in structures include the bridge pier foundations, offshore gravity-based structures, locks and dams, immersed concrete tunnels, and storm or tidal surge barriers.

In 1943, the first prestressed concrete barge was built by the U.S. Navy (U.S. Department of Transportation [USDOT] 1981). Today, the preferred construction approach for large structures is to use prestressed concrete instead of ordinary reinforced concrete. The ability of prestressed structures to control net tensile stresses and to close cracks that develop from temporary overload situations enhances water tightness and durability. Composite concrete-steel construction is also becoming popular. Concrete is used in the exterior bulkheads and base to provide durability, and steel is used for the internal framing and deck to provide weight savings (Gerwick 1975a, 1978).

The design of concrete floating structures requires knowledge of many disciplines. The designer should have a thorough understanding of concrete design principles, concrete as a material, and construction practice. Also, the designer should have an understanding of environmental loadings, marine operations, requirements for vessel certification, and the importance of structure inspection, maintenance, and repair. All of these aspects have been addressed in this report to provide the reader with a background in the subject of concrete floating structures.

1.2—Scope

This report is intended to further the development of floating concrete structures by presenting relevant design, materials, construction, installation, maintenance, and repair. Application of available technology is demonstrated for a range of floating concrete structures to show that technological risks are at a known and acceptable level.

The report starts with a historical presentation of floating structures and design concepts to establish both the versatility and technical viability of concrete floating marine structures. The durability and serviceability of floating structures at remote sites are important considerations to project planners and developers. Recommendations for design loads and design criteria are presented. Design procedures and methods of analysis are discussed to better acquaint the reader with the design considerations unique to floating marine structures.

CHAPTER 2—NOTATION, DEFINITIONS, AND ACRONYMS

2.1—Notation

A_i = free surface in partially filled compartment, ft^2 (m^2)
B = beam (width) of a floating structure, in. (m)
BM = distance from center of buoyancy to metacentric point, in., (m)
D = draft, in. (m)
$F(t)$ = external force due to waves, lb (kN)
j = total number of load blocks considered
KB = distance from keel to center of buoyancy, in. (m)
KG = distance from keel to center of gravity, in. (m)
ℓ = length, in. (m)
M_{sw} = still-water bending moment, in.-lb (m-kN)
M_t = total bending moment, in.-lb (m-kN)