Guide to Design and Construction of Circular Wire- and Strand-Wrapped Prestressed Concrete Structures

Reported by ACI Committee 372

First Printing
December 2013

American Concrete Institute®
Advancing concrete knowledge

Guide to Design and Construction of Circular Wire- and Strand-Wrapped Prestressed Concrete Structures

The technical committees responsible for ACI committee reports and standards strive to avoid ambiguities, omissions, and errors in these documents. In spite of these efforts, the users of ACI documents occasionally find information or requirements that may be subject to more than one interpretation or may be incomplete or incorrect. Users who have suggestions for the improvement of ACI documents are requested to contact ACI via the errata website at www.concrete.org/committees/errata.asp. Proper use of this document includes periodically checking for errata for the most up-to-date revisions.

ACI committee documents are intended for the use of individuals who are competent to evaluate the significance and limitations of its content and recommendations and who will accept responsibility for the application of the material it contains. Individuals who use this publication in any way assume all risk and accept total responsibility for the application and use of this information.

All information in this publication is provided "as is" without warranty of any kind, either express or implied, including but not limited to, the implied warranties of merchantability, fitness for a particular purpose or non-infringement.

ACI and its members disclaim liability for damages of any kind, including any special, indirect, incidental, or consequential damages, including without limitation, lost revenues or lost profits, which may result from the use of this publication.

It is the responsibility of the user of this document to establish health and safety practices appropriate to the specific circumstances involved with its use. ACI does not make any representations with regard to health and safety issues and the use of this document. The user must determine the applicability of all regulatory limitations before applying the document and must comply with all applicable laws and regulations, including but not limited to, United States Occupational Safety and Health Administration (OSHA) health and safety standards.

Participation by governmental representatives in the work of the American Concrete Institute and in the development of Institute standards does not constitute governmental endorsement of ACI or the standards that it develops.

Order information: ACI documents are available in print, by download, on CD-ROM, through electronic subscription, or reprint and may be obtained by contacting ACI.

Most ACI standards and committee reports are gathered together in the annually revised ACI Manual of Concrete Practice (MCP).

American Concrete Institute
38800 Country Club Drive
Farmington Hills, MI 48331
U.S.A.
Phone: 248-848-3700
Fax: 248-848-3701

www.concrete.org

ISBN: 978-0-87031-851-1

ACI 372R-13

Guide to Design and Construction of Circular Wire- and Strand-Wrapped Prestressed Concrete Structures

Reported by ACI Committee 372

Daniel J. McCarthy, Chair — Andrew R. Minogue, Secretary

Jon B. Ardahl, Ashok K. Dhingra, Kenneth R. Harvey, Charles S. Hanskat, Atis A. Liepins, Ramon E. Lucero, Salvatore Marques, Justin Norvell, Morris Schupack, Marwan N. Youssef

This guide provides recommendations for the design and construction of circular, wrapped, prestressed concrete structures commonly used for liquid or bulk storage. These structures are constructed using thin cylindrical shells of either concrete or shotcrete. Shotcrete and precast concrete core walls incorporate a thin steel diaphragm that serves both as a liquid barrier and vertical reinforcement. Cast-in-place concrete core walls incorporate either vertical prestressing or a steel diaphragm. Recommendations are given for circumferential prestressing achieved by wire or strand wrapping. In wrapping, the wire or strand is fully tensioned before placing it on the structural core wall. Procedures for preventing corrosion of the prestressing elements are emphasized. The design and construction of dome roofs are also covered.

Many recommendations of this guide can also be applied to similar structures containing low-pressure gases, dry materials, chemicals, or other materials capable of creating outward pressures. This guide is not intended for application to nuclear reactor pressure vessels or cryogenic containment structures.

Keywords: circumferential prestressing; dome; footing; joint sealant; prestressed concrete; prestressing steel; shotcrete; wall.

CONTENTS

ACI 372R-13 supersedes ACI 372R-03 and was adopted and published December 2013.

CHAPTER 1—GENERAL

1.1—Introduction

The design and construction of circular prestressed concrete structures requires specialized engineering knowledge and experience. The recommendations herein reflect over 6 decades of experience in designing and constructing circular prestressed structures. When designed and built with understanding and care, these structures can be expected to serve for well over 50 years without requiring significant maintenance.

1.2—Objective

This guide provides recommendations for the design and construction of circular wire- and strand-wrapped prestressed concrete structures based on practices used in successful projects.

1.3—Scope

The recommendations supplement the general requirements for reinforced concrete and prestressed concrete design and construction given in ACI 350 and ACI 350.5. Design and construction recommendations cover the following elements or components of circular-wrapped prestressed concrete structures:

a) Floors
  i) Reinforced concrete
b) Floor-wall connections
  i) Hinged
  ii) Fixed
  iii) Partially fixed
  iv) Unrestrained
  v) Changing restraint
c) Walls
  i) Cast-in-place concrete walls with steel diaphragms or vertical prestressing
  ii) Shotcrete walls with steel diaphragms
  iii) Precast concrete walls with steel diaphragms
d) Wall-roof connections
  i) Hinged
  ii) Fixed
  iii) Partially fixed
  iv) Unrestrained
e) Roofs
  i) Concrete dome roofs with a prestressed dome ring, constructed with cast-in-place concrete, shotcrete, or precast concrete
  ii) Flat concrete roofs
f) Wall and dome ring prestressing systems
  i) Circumferential prestressing using wrapped wire or strand systems
  ii) Vertical prestressing using single or multiple high-strength strands or bars

1.4—Associated structures

Baffle walls and inner storage walls are frequently constructed inside water storage tanks. Baffle walls are used to increase the chlorine retention time of water as it circulates from the tank inlet to the outlet. The configuration and layout of baffle walls vary depending on the tank geometry, flow characteristics, and the desired effectiveness of the chlorination process. The most common baffle wall configurations are straight, C-shaped, or a combination of the two. Baffle walls can be precast or cast-in-place concrete, masonry block, redwood, shotcrete, metal, or fabric.

Inner storage walls are separate storage cells normally used to provide flexibility in a system's water storage capabilities and hydraulics. Inner walls are typically constructed the same as the outer tank walls and are designed for external and internal hydrostatic pressure.

1.5—History and development

Hewett (1923) first applied circumferential prestressing to a concrete water tank using turnbuckles to connect and tension individual steel tie rods. Long-term results were not effective because the steel used was of low yield strength, limiting applied unit tension to approximately 30,000 psi (210 MPa). Shrinkage and creep of the concrete resulted in a rapid and almost total loss of the initial prestressing force. E. Freyssinet was the first to realize the need to use steel of high quality and strength, stressed to relatively high levels, to overcome the adverse effects of concrete creep and shrinkage (Mautner 1936). Freyssinet successfully