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Design and Construction of Circular Prestressed Concrete Structures with Circumferential Tendons

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FOREWORD

This report provides recommendations for the design and construction of circular prestressed concrete structures (commonly referred to as "tanks") post-tensioned with circumferential tendons. These thin cylindrical shells of either cast-in-place or precast concrete are commonly used for liquid and bulk storage. Vertical post-tensioning is often incorporated in the walls as part of the vertical reinforcement. Recommendations are applicable to circumferential prestressing achieved by post-tensioning tendons placed within the wall or on the exterior surface of the wall. Procedures to prevent corrosion of the prestressing elements are emphasized. The design and construction of dome roofs are also covered.

Keywords: circumferential prestressing; concrete; corrosion resistance; domes; floors; footings; joints; loads (forces); prestressed concrete; prestressed reinforcement; reinforcing steel; roofs; shotcrete; shrinkage; tanks; temperature; tendons; walls.

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CHAPTER 1—GENERAL

1.1—Introduction

The design and construction of circular prestressed concrete structures using tendons requires specialized engineering knowledge and experience. This report reflects over four decades of experience in designing and constructing circular prestressed concrete structures with tendons. When designed and constructed by knowledgeable individuals, these structures can be expected to serve for fifty years or more without requiring significant maintenance.

This report is not intended to prevent development or use of new advances in the design and construction of circular prestressed concrete structures. This report is not intended for application to nuclear reactor pressure vessels or cryogenic containment structures.

This report describes current design and construction practices for tanks prestressed with circumferential post-tensioned tendons placed within or on the external surface of the wall.

1.2—Objective

The objective of this report is to provide guidance in the design and construction of circular prestressed concrete structures circumferentially prestressed using tendons.

1.3—Scope

The recommendations in this report are intended to supplement the general requirements for reinforced concrete and prestressed concrete design, materials and construction, given in ACI 318, ACI 301 and ACI 350R.

This report is concerned principally with recommendations for circular prestressed concrete structures for liquid storage. The recommendations contained here may also be applied to circular structures containing low-pressure gases, dry materials, chemicals, or other materials capable of creating outward pressures. The recommendations may also be applied to domed concrete roofs over other types of circular structures. Liquid storage materials include water, wastewater, process liquids, cement slurry, petroleum, and other liquid products. Gas storage materials include gaseous by-products of waste treatment processes and other gaseous material. Dry storage materials include grain, cement, sugar, and other dry granular products.

The recommendations in this report may also be applicable to the repair of tanks using externally applied tendons.

Design and construction recommendations cover the following elements or components of tendon tanks:

a. Floors
- Prestressed Concrete
- Reinforced Concrete

b. Floor-Wall Joints
- Hinged
- Fixed
- Partially Fixed
- Unrestrained
- Changing Restraint

c. Walls
- Cast-in-Place Concrete
- Precast Concrete

d. Wall-Roof Joints
- Hinged
- Fixed
- Partially Fixed
- Free

e. Roofs
- Concrete Dome Roofs with Prestressed Dome Ring
  (1) Cast-in-place Concrete.
  (2) Shotcrete.
- Other Roofs
  (1) Prestressed Concrete.
  (2) Reinforced Concrete.

f. Wall and Dome Ring Prestressing Methods
- Circumferential

(1) Individual high-strength strands in plastic sheaths or multiple high-strength strand tendons in ducts positioned within the wall and post-tensioned after placement and curing of the wall concrete, as shown in Fig. 1.1.

(2) Individual or multiple high-strength strands and, less frequently, individual high-strength bar tendons, prestressed after being positioned on the exterior surface of the wall.

- Vertical

(1) Individual or multiple high-strength strand or individual high-strength bar tendons, enclosed in sheathing or ducts within the wall, anchored near the wall joints at the bottom and top of the wall.

(2) Pretensioned high-strength strands in precast panels.

1.4—History and development

The late Eugene Freyssinet, a distinguished French engineer generally regarded as the father of prestressed concrete, was the first to recognize the need to use steels of high quality and strength, stressed to relatively high levels, in