ISO 18407:2018 (E)

Simplified design of prestressed concrete tanks for potable water

Contents

Foreword

Introduction

1 Scope

2 Normative references

3 Terms and definitions

4 Symbols

5 Design principles

6 Load

- 6.1 General
- 6.2 Deadweight
- 6.3 Imposed load
- 6.4 Hydrostatic water pressure
- 6.5 Prestress
- 6.5.1 General
- 6.5.2 Prestressing force immediately after prestressing
- 6.5.3 Effective prestressing force
- 6.5.4 Indeterminate forces due to prestress
- 6.6 Creep and drying shrinkage of concrete
- 6.7 Effect of temperature
- 6.8 Seismic action
- 6.9 Wind load
- 6.10 Snow load
- 6.11 Earth pressure
- 6.12 Uplift pressure force
- 6.13 Other loads

7 Structural analysis

- 7.1 Calculation of member force
- 7.2 Concrete
- 7.2.1 Strength
- 7.2.2 Modulus of elasticity
- 7.2.3 Poisson’s ratio
- 7.2.4 Drying shrinkage
- 7.2.5 Creep
- 7.3 Steel
- 7.3.1 Strength
- 7.3.2 Modulus of elasticity
- 7.3.3 Relaxation
- 7.4 Calculation of tensile reinforcement

8 Stress limit

- 8.1 General
- 8.2 Stress limit of reinforced concrete members
- 8.2.1 Stress limit of concrete
- 8.2.2 Stress limit of reinforcement
- 8.3 Stress limit of prestressed concrete members
- 8.3.1 Stress limit of concrete

8.3.2 Tensile stress limit of prestressing steel
8.3.3 Stress limit of reinforcement
8.3.4 Augmentation of tensile stress limit of concrete

9 Verification of safety against earthquake

9.1 Principles of seismic design
9.1.1 General
9.1.2 Ground motion levels
9.1.3 Levels of earthquake resistance
9.1.4 Effects of earthquake
9.1.5 Seismic design procedure
9.2 Input earthquake motion
9.2.1 Seismic design method
9.2.2 Design seismic coefficients for the seismic coefficient method for Level 1 ground motion
9.2.3 Design seismic coefficients for the seismic coefficient method for Level 2 ground motion
9.2.4 Seismic input for design by dynamic analysis
9.3 Verification of structural safety
9.3.1 Effects of earthquake
9.3.1.1 General
9.3.1.2 Inertia force derived from deadweight, etc
9.3.1.3 Dynamic water pressure during an earthquake
9.3.2 Combination of loads
9.3.3 Calculation of member forces
9.3.4 Safety verification
9.4 Investigation for foundation

10 General structural details

10.1 Prestressing steel
10.1.1 Clear distance
10.1.2 Concrete cover
10.1.3 Arrangement of curved prestressing steel
10.1.4 Arrangement of anchorages and couplers
10.1.5 Protection of anchorage zone
10.1.6 Reinforcement of concrete near anchorages
10.2 Steel reinforcement
10.2.1 Clear distance
10.2.2 Concrete cover
10.2.3 Bend configurations of reinforcement
10.2.4 Splices in reinforcement
10.2.5 Anchoring of reinforcement
10.2.6 Welded wire fabric
10.3 Concrete joints
10.3.1 Construction joints
10.3.2 Joints between precast concrete members
10.4 Reinforcement for opening

11 Design of members

11.1 Method of calculating member force
11.1.1 Analysis method
11.1.2 Analysis model
11.2 Component division
11.3 Roof
11.3.1 Structural types
11.3.2 Design in general
11.3.2.1 Loads for roof design
11.3.2.2 Design of a spherical dome
11.3.2.3 Design of the dome ring
11.3.2.4 Design of slab roof
11.4 Tank wall
11.4.1 Structural types
11.4.2 Design in general
11.4.2.1 Loads for tank wall

11.4.2.2 Combinations of loads
11.4.2.3 Design of the tank wall
11.4.2.4 Method of applying prestress
11.4.2.5 Pilasters
11.4.2.6 Design of the tank wall bottom
11.5 Base slab
11.5.1 Structural types
11.5.2 Design in general
11.5.2.1 Loads for base slab
11.5.2.2 Load combinations
11.5.2.3 General design of base slab
11.5.2.4 One-layer base slab structure
11.5.2.5 Two-layer base slab structure

12 Materials

12.1 Quality of materials
12.1.1 General
12.1.2 Concrete materials
12.1.2.1 Cement
12.1.2.2 Water
12.1.2.3 Fine aggregate
12.1.2.4 Coarse aggregate
12.1.2.5 Admixtures
12.1.3 Concrete
12.1.3.1 General
12.1.3.2 Strength
12.1.4 Prestressing steel
12.1.5 Steel reinforcement
12.1.6 Welded wire fabric
12.1.7 Anchorages and couplers
12.1.8 Sheath
12.1.9 Coating materials for protecting prestressing steel
12.1.9.1 Grout for prestressed concrete
12.1.9.2 Coating materials for unbonded prestressing steel

13 Tank appurtenances

13.1 Ladders/stairs and handrails
13.2 Manhole and water pilot hole
13.3 Ventilators
13.4 Lightning rods
13.5 Piping
13.6 Catch basin
13.7 Water-level gauge
13.8 Rainwater treatment
13.9 Protection equipment

Annex A (informative) Reference design flow

Annex B (informative) Design seismic coefficients for the seismic coefficient method

B.1 Level 1 ground motion
B.2 Level 2 ground motion

Annex C (informative) Seismic input for design by dynamic analysis

Annex D (informative) Example of material specifications

D.1 Concrete
D.1.1 Modulus of elasticity
D.1.2 Drying shrinkage
D.1.3 Creep
D.2 Steel
D.2.1 Modulus of elasticity
D.2.2 Relaxation
D.3 Stress limit
D.3.1 Stress limit of reinforced concrete members

D.3.1.1 Stress limit of concrete
D.3.1.2 Stress limit of reinforcement
D.3.2 Stress limit of prestressed concrete members
D.3.2.1 Stress limit of concrete
D.3.2.2 Tensile stress limit of prestressing steel
D.3.2.3 Stress limit of reinforcement
D.3.2.4 Augmentation of tensile stress limit of concrete

Annex E (informative) Example of design calculation

E.1 Outline
E.1.1 Outline of design
E.1.2 Outline of the structure
E.2 Design conditions
E.2.1 Basic dimensions and general shape
E.2.2 Construction site and ground conditions
E.2.3 Design loads
E.2.3.1 Classifications of design loads
E.2.3.2 Load type and load intensity
E.2.4 Materials properties
E.2.4.1 Concrete
E.2.4.2 Prestressing steel
E.2.4.3 Reinforcing bars
E.2.4.4 Stress loss of prestressing steel
E.2.5 Stress limit
E.2.6 Material strength
E.2.7 Material factor
E.2.8 Minimum reinforcement and minimum cover depth
E.3 Design of the dome roof
E.3.1 Design conditions
E.3.2 Cross-section force acting on the dome
E.3.2.1 Calculation of the dome load
E.3.2.2 Stress generated in the dome
E.3.3 Steel reinforcement arrangement of the dome
E.4 Design of the dome ring
E.4.1 Design conditions
E.4.2 Calculation of horizontal thrust
E.4.2.1 Loads on the dome
E.4.2.2 Dome horizontal thrust
E.4.3 Design of prestressing force
E.4.3.1 Centre positions of prestressing steel
E.4.3.2 Section size of pilaster
E.4.3.3 Required prestressing force
E.4.3.4 Calculation of the effective tensile force of prestressing steel
E.4.3.5 Prestressing steel arrangement in the circumferential direction
E.5 Design of wall
E.5.1 Design conditions
E.5.2 Calculation of cross-section force
E.5.2.1 Basic formula and solution
E.5.2.2 M0 and Q0 at the wall bottom
E.5.2.3 Bending moment, shearing force and circumferential axial force at an arbitrary point
E.5.2.4 Stress due to deadweight
E.5.2.5 Stress due to imposed load
E.5.2.6 Cross-section force incorporating the effects of the haunch at wall bottom and elastic fixation
E.5.3 Design of circumferential prestressing force
E.5.3.1 Centre positions of prestressing steel
E.5.3.2 Section size of pilaster
E.5.3.3 Calculation of the effective tensile force of prestressing steel
E.5.3.4 Required prestressing force
E.5.3.5 Arrangement of circumferential prestressing steel
E.5.4 Design of vertical prestressing force
E.5.4.1 Calculation of effective prestressing force
E.5.4.2 Axial force and eccentric moment due to vertical prestressing steel
E.5.4.3 Cross-section force and stress at wall bottom for selecting vertical prestressing steel

E.5.4.4 Required prestressing force
E.5.4.5 Number of vertical prestressing steel required
E.5.4.6 Stress due to vertical prestressing force
E.5.5 Cross-section force and stress of the tank wall
E.5.6 Combined stress
E.5.7 Verification regarding shear
E.5.7.1 General
E.5.7.2 Shear stress
E.5.7.3 Diagonal tensile stress
E.5.8 Verification of safety against an earthquake
E.5.8.1 Calculation of cross-section force
E.5.8.2 Verification with respect to Level 1 ground motion
E.5.8.3 Verification with respect to Level 2 ground motion
E.5.8.4 Verification of sloshing height
E.6 Design of base slab
E.6.1 Design of base slab
E.6.2 Ring plate length
E.6.3 Calculation of cross-section force
E.6.3.1 Design load
E.6.3.2 Modelling
E.6.3.3 Calculation of cross-section force
E.6.4 Bar arrangement of base slab
E.6.4.1 Minimum reinforcement content
E.6.4.2 Calculation of reinforcement content
E.6.4.3 Calculation of reinforcement content
E.6.5 Verification of safety against an earthquake
E.6.5.1 Verification with respect to Level 1 ground motion
E.6.5.2 Verification with respect to Level 2 ground motion
E.7 Stability calculation
E.7.1 Horizontal force and overturning moment
E.7.1.1 Deadweight
E.7.1.2 Overturning moment due to dynamic water pressure
E.7.2 Verification of bearing capacity
E.7.3 Verification regarding sliding
E.7.4 Verification regarding overturning

Page count: 174