

**SECTION 03240 - CIRCULAR PRESTRESSED CONCRETE TANKS  
(STRAND WRAP SYSTEM)**

**City of San Diego, CWP Guidelines**

**PART 1 -- GENERAL**

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NTS: The DESIGN CONSULTANT shall coordinate the foundation and roof design with the design of the wall and shall make appropriate changes to this Section of specifications based on such coordination. THE DESIGN CONSULTANT shall also comply with the requirements of the Structural Design Guidelines, Appendix D, Chapter D3 of MWWD's Clean Water Program Guidelines.

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**1.1 WORK OF THIS SECTION**

- A. The WORK of this Section includes providing circular prestressed concrete tank using machine strand-wrap system, including circumferential and vertical prestressing, shotcreting and including designing the tank and the prestressing system, complete with all appurtenances as required and as indicated. The Tank Subcontractor shall be OWNER-approved.
- B. The WORK requires that one OWNER-approved Prestressed Concrete Tank Subcontractor be given responsibility for the indicated WORK, but without altering the CONTRACTOR'S responsibilities under the Contract Documents.
- C. The Prestressed Concrete Tank Subcontractor shall not sublet the wall foundations, slabs, cast-in-place walls with embedded PVC waterstops, rubber pads, seismic cables, anchors for prestressing vertical tension units, internal PVC lining, roof slabs, horizontal machine strand-wrapped prestressing or shotcreting work.

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NTS: The DESIGN CONSULTANT shall prepare a list of candidate Prestressed Concrete Tank Subcontractors from which list the OWNER will select and approve the Prestressed Concrete Tank Subcontractor for the project.

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**1.2 PRESTRESSED CONCRETE TANK SUBCONTRACTORS**

- A. The following Subcontractors have been listed for the WORK:
  - 1. DYK Inc.
  - 2. Preload Inc.
  - 3. [or equal]

**1.3 QUALIFICATIONS, APPROVAL, AND DOCUMENTATION OF SUBCONTRACTORS**

- A. **Qualifications:** The Prestressed Concrete Tank Subcontractor shall have the following:
  - 1. At least one successful project of comparable size and complexity constructed in the recent past.
  - 2. Ability to obtain performance and payment bonds for the Work of this Section.

3. Possessing ( at the time of bid submittal) of at least two operable strand wrapping and automated shotcrete machines meeting the requirements specified herein.
- B. **Approval:** Bidders shall submit the name and documented qualifications of the Prestressed Concrete Tank Subcontractor for the project. The OWNER will review and approve the proposed selection.
- C. Documentation to be submitted CONTRACTOR
1. Documentation indicating that the proposed Tank Subcontractor has at least one project of comparable size and complexity constructed in the recent past.
  2. The name, telephone number, and address of the owner and the completion date and location of at least one structure on which the proposed strand wrap system, meeting the requirements of these Specifications, had been constructed.
  3. The name of the proposed superintendents who will be in direct charge of the tank construction and their respective experience in the construction of the specified tanks.
  4. A list of tank projects successfully completed by each of the superintendents, which shall include a job description, the name, telephone number, and address of the owner, construction manager, and completion date.
  5. Descriptive literature for the wrapping and shotcrete equipment proposed for use and meeting these specification requirements.
  6. Photographs or prints of the means of recording the circumferential prestressing application and copies of actual photographs, printouts, or other records of applied wrapping forces taken from jobs in which the proposed wrapping equipment has been used.
  7. Financial prospectus indicative of the corporate financial state. The prospectus shall include a letter from a financial institution verifying the capability for securing bonds for the Work of this Section.
  8. The name of the Professional Civil or Structural Engineer, currently licensed in the State of California and employed by the Tank Subcontractor, who will design the prestressed concrete tanks under this Contract. The location and date of design of tanks meeting this Specification of equivalent capacity shall be included. The design engineer must have been employed full-time by the Tank Subcontractor and have been directly involved in the design of the listed projects having comparable size and complexity. The CONTRACTOR shall submit the name of the tank designer on the "Certificate of Design" included at the end of this Section 03240.

#### 1.4 RELATED SECTIONS

- A. The WORK of the following Sections applies to the WORK of this Section. Other Sections of the Specifications, not referenced below, shall also apply to the extent required for proper performance of this WORK.
1. Section 02667 - Testing and Disinfection of Hydraulic Structures
  2. Section 03100 - Concrete Formwork
  3. Section 03200 - Reinforcement Steel
  4. Section 03290 - Joints in Concrete Structures



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|------------------|--|
| 10. ACI 506.2-90 | Specifications for Materials, Proportioning and Application of Shotcrete |
| 11. UBC-97       | Uniform Building Code  |
| 12. AWWA D 110   | Wire- and Strand-Wound, Circular, Prestressed Concrete Water Tank        |

## 1.7 SHOP DRAWINGS AND SAMPLES

- A. The following shall be submitted in compliance with Section 01300:
1. Shop drawings of tank consisting of concrete roof, concrete floor and a cast-in-place concrete core wall reinforced vertically with post tensioning bars and circumferentially with wrapped strand and protected with shotcrete.
  2. Circumferential wrapping schedule and the intermediate lock-off positions and elevations.
  3. Detail and location of all joints in concrete.
  4. Detail of all appurtenances as indicated and as required for a complete job.
  5. Detail of all reinforcing steel.
  6. Details of Prestressing and Post-Tensioning:
    - a. Design calculations, fabrication details, and erection drawings of prestressing and post-tensioning, including anchors.
    - b. Design calculations shall include initial and final prestressing forces and stress losses due to plastic flow, shrinkage in the concrete, creep in the steel, anchorage losses, and machine tolerances as specified.
    - c. Design calculations shall be sealed by a Professional Civil or Structural Engineer registered in the State of California.
  7. Product Data: Furnish pertinent information as follows:
    - a. Grout for vertical prestressing: Two-part water-insensitive epoxy intended for use in grouting tendon ducting.

## 1.8 OWNER'S MANUAL

- A. The following shall be included in the OWNER'S MANUAL in compliance with Section 01300:
1. Calculations for the structural design of the tank, stamped by a Professional Civil or Structural Engineer registered in the State of California. The calculations will be reviewed, and retained in the OWNER'S file.
  2. Certified mill reports on the prestressing steel showing the dimensional and physical characteristics as indicated including ultimate strength, the modulus of elasticity, and percentage of elongation at rupture for each size, heat or reel of prestressing steel.

These values shall conform to the indicated ASTM specifications. Reports shall be provided prior to stressing.

3. Certificates of calibration of all recording equipment to be used in the prestressing application.
4. Stressing Records: Continuous graphical record of circumferential wrapping forces applied to the strand, and force-elongation record of the vertical stressing system.

#### 1.9 TESTING LABORATORY

- A. To demonstrate conformance with the specified requirements for tank prestressing, the CONTRACTOR shall provide the services of a laboratory which is a member of the American Council of Independent Laboratories and which complies with the requirements of ASTM E 329. The testing laboratory shall calibrate and certify all recording equipment, perform all testing and provide all test certificates as indicated.

#### 1.10 PRECONSTRUCTION TESTING

- A. The Tank Subcontractor shall make vertical test panels at least 30-inch by 30-inch for each concrete mix being considered. Test panels shall contain the same reinforcement as in the tank wall shotcrete in at least half of the panel to test for proper embedment of reinforcing steel. Fabricate vertical test panels to the same thickness as the WORK, but not less than 3 inches. Take at least five cubes or cores from the panels for testing.
- B. All cut or broken surfaces on test panels shall be dense and free of laminations and sand pockets.
- C. Test for compressive strength in compliance with ASTM C42.
- C. Test panels shall be made by each application crew using the equipment, materials, and mix proportions for the project.

#### 1.11 DETERMINATION OF COMPRESSIVE STRENGTH DURING CONSTRUCTION

- A. The compressive strength of the shotcrete will be determined by the CONSTRUCTION MANAGER through the medium of [2inch by 4-inch] test cylinders or [4-inch cubes].
- B. Cubes may be sawed, or cores may be drilled from panels prepared especially for testing purposes. All cut surfaces shall be dense and free from sand pockets.
- C. To establish a correlation between the 2-inch by 4-inch cylinders or 4-inch cubes and the standard 6-inch by 12-inch cylinders, a series of four, 6-inch by 12-inch test cylinders shall be made by coring concrete cylinders from 12-inch deep by 30-inch by 14-inch shotcrete specimen blocks. The specimen blocks shall be shot in one continuous operation to the required height of the block onto a back form of plywood laid on the ground.
- D. One concrete test panel shall be made during each day's operation. Three specimens shall be cut from each concrete panel 7 days after its placing. One cylinder will be tested for the 7-day strength, the other two will be tested at 28 days. The remainder of the concrete panel shall be cured and stored until after the 28-day test has been made and until the CONSTRUCTION MANAGER has informed the Tank Subcontractor, in writing, that no additional specimens have to be cut and tested. All concrete specimens shall be properly

numbered and dated and a record shall be made by the Tank Subcontractor as to the location of the WORK for which these samples were prepared.

- E. In lieu of concrete test panels, concrete cylinders may be taken directly out of delivery tanks and tested in accordance with Section 03300.

#### 1.12 FIELD TESTING OF TANK

- A. The tank shall be tested for leakage in accordance with the provisions of Section 02667.

#### 1.13 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Prestressing steel shall be adequately packaged against intrusion of chemical contaminants (from the atmosphere or otherwise) for the protection of the steel against physical damage and corrosion during (and subsequently as the result of) shipping and storage.
- B. Prestressing steel that has sustained physical damage through rust or otherwise will be rejected.
- C. All materials delivered to the job site shall be stored off the ground on planks, supported by 4-inch by 4-inch timber, which must be covered with polyethylene or sisal-kraft paper to prevent any moisture from coming up from the bottom.
- D. Reels of strand, threaded bars, anchorages, etc., shall be stacked neatly and as compact as possible.
- E. All materials shall be covered with tarpaulins in such a manner that water, rain, moisture and dust are kept away.

## PART 2 -- PRODUCTS

### 2.1 GENERAL

- A. The Tank Subcontractor shall furnish the structural design for at least one successful prestressed concrete tank of comparable size and complexity constructed in the recent past. The tank must have been designed and stamped by a Professional Civil or Structural Engineer registered in the State of California. The Professional Civil or Structural Engineer shall have experience in the design of the type of tanks specified and must currently be in the full time employment of the Tank Subcontractor.
- B. The word "wire" as used in this Section refers to strand, and the words "stressing machine" refer to the circumferential strand wrapping machinery or vertical tendon apparatus.

### 2.2 DESIGN CRITERIA

- A. **General:**
  1. These Specifications set the minimum requirements which must be used as a basis for all circular prestressed concrete tank designs which use the strand-wrap system. Alternate designs which do not incorporate machine strand wrapping with continuous electronic recording of prestressing forces shall not be considered.

2. All circumferential prestressing of tank walls shall be done with hot-dipped galvanized seven-wire strand conforming to these Specifications and placed on the exterior of the cast-in-place corewall. Systems which utilize machine wrapped wire in lieu of strand shall not be accepted. No system which relies on pulling the wire through a die, to provide a tensioning force, will be allowed. Vertical prestressing shall be provided using galvanized, threaded bar. Wire wrapping shall not be accepted in lieu of strand wrapping.
3. Only designs incorporating cast-in-place corewalls will be accepted. No corewalls manufactured by precasting or shotcreting will be allowed.
4. Tank wall systems based on rod type tendons involving the circumferential movement of prestressing steel relative to the wall surface shall not be considered. Tank wall systems which utilize strand cables placed circumferentially inside of ducts cast in the corewall or strands manually placed externally around the corewall shall not be acceptable.
5. Tank wall designs shall not be based on stress-tolerance and stress-loss deductions less than those indicated in these Specifications.
6. Clearance between wrapped strands, in any vertical layer, shall not be less than 2.5 strand diameters or 3/8-inch whichever is greater.
7. Tank wall designs shall not be based on wrapping tolerances less than what the wrapping machinery can factually and continuously meet based on continuous electronically recorded print-outs taken from earlier projects.
8. Each intermediate strand layer shall be covered with shotcrete of 3/8-inch thickness over the steel. The minimum cover over the final strand layer shall be 1.5 inches.

**B. Tank Wall Design:**

**1. Circumferential Prestressing:**

- a. Minimum total wall thickness at any height: 9.875 inches  
Minimum core-wall thickness at any heights: 8.00 inches

(Total wall thickness includes a cast-in-place core-wall and a 1.5 inch minimum shotcrete cover over the circumferential prestressing strand. The core-wall is the portion of the wall interior of all circumferential prestressing.)

**b. Minimum Final Circumferential Prestressing Force for Water Load:**

The minimum final circumferential prestressing force to contain the waterload at the bottom of the wall shall be:

$$P_{cw} = 70 (R) (H)$$

Where:  $P_{cw}$  = Minimum final prestressing force in lbs per ft of height

$R$  = inside radius of wall, feet

$H$  = maximum overflow water height, feet

This force shall taper uniformly to zero at the top of the maximum overflow height.

c. **Minimum Final Circumferential Prestress for Differential Temperature and Dryness Bending (Pctd):**

The minimum total "final" circumferential compression at any height on the wall, for above-ground wall conditions shall be 200 psi over the waterload and after deduction of all losses.

d. **Minimum Circumferential Backfill Force on Wall (Pcb):**

$$Pcb = (h)(p)(R + 0.0833 t)$$

Where: Pcb = Minimum circumferential backfill force in pounds per foot of height

h = height of soil above wall-footing, feet

p = equivalent liquid backfill pressure, lbs/cf

t = total wall thickness including cover over prestressing strands, inches

e. **Maximum Final Stress in Circumferential Prestressing Steel (fse):**

The final circumferential stress (fse) in prestressing steel shall be determined as follows:

Start with the initial average steel stress. This value shall not exceed 70 percent of the minimum ultimate strength (MUS) of steel, based on a maximum allowable stress tolerance of plus or minus 1.5 percent MUS.

Deduct therefrom a stress loss of 25,000 psi.

The balance is considered the design stress (fse)

f. **Maximum compressive stress in concrete walls:**

The maximum compressive stress in concrete walls, under any combination of load conditions, at any stage during the construction and without any allowance for stress losses due to creep of steel and concrete, or due to elastic deformation of concrete, shall not exceed 0.55 f'c.

g. **Minimum Circumferential Prestressing Steel Requirement:**

$$Acp = \frac{Pcw + Pctd}{fse}$$

Where: Acp = area of prestressing steel in square inch per foot of height

Pcw = the minimum final circumferential prestressing force to contain the waterload, lbs/ft of height



Pctd = the minimum final circumferential prestressing force for differential temperature and dryness, lbs/ft of height

fse = the final stress in the circumferential prestressing strand, psi

2. **Vertical Prestressing:** Vertical prestressing shall be designed to resist bending loads without inducing tension in the concrete. The minimum compressive stress in the wall due to prestressing after all losses shall be 200 psi.
3. **Minimum Vertical Steel Requirement:** Cast-in-place concrete tank walls, reinforced vertically with galvanized prestressing bars, shall be reinforced further on the inside of the tank wall with #5 bars spaced, on average, no further apart than 24-inch on centers.
4. **Seismic Design:** Seismic design shall be in accordance with "Housner Method" for hydrodynamic forces and ACI 318. The wall base design detail shall permit free radial movement on the footing. Seismic forces shall be resisted by the indicated earthquake cable.

## 2.3 MATERIAL REQUIREMENTS

### A. Circumferential Prestressing (CP) and Earthquake Cables (EQ):

1. Hot-dipped galvanized seven-wire strand used for circumferential prestressing and earthquake cables shall meet the following minimum requirements:

|   | <u>CP &amp; EQ</u> | <u>EQ</u>         |
|---|--------------------|-------------------|
| a. Nominal strand diameter, in.               | 3/8                | 1/2               |
| b. Nominal area after galv., sq. in.          | 0.089              | 0.153 before galv |
| c. Nominal weight/100 LF, lbs                 | 303                | -                 |
| d. Pitch, strand dia                          | 12 - 16            | -                 |
| e. Tensile strength, lbs                      | 21,400             | 32,250            |
| f. Yield strength @ 1% extension, lbs         | 16,000             | 28,500            |
| g. Elongation in 24-inch at fracture, percent | 4.5                | 4.5               |
| h. Weight of zinc coating, oz/sq. ft          | 0.85               | 0.85              |

2. Hot-dipped galvanized seven-wire strand shall be manufactured in accordance with ASTM A416 prior to galvanizing.

### B. Vertical Prestressing:

1. Vertical prestressing bars shall be galvanized, high strength thread bars suitable for mechanically coupling lengths of bar and for positive attachment of anchor assemblies. Bars shall conform to ASTM A722 requirements, as modified herein, stress relieved, and shall be uniform such that any length of bar may be cut at any

point and the internal threads of coupling designated for that size of bar can be freely screwed on the bar. Quenched and tempered steels will not be allowed. Bars shall meet the following minimum requirements:

|    |  |       |       |
|----|--|-------|-------|
| a. | Diameter, in.                              | 1-1/4 | 1-3/8 |
| b. | Tensile force, kips                        | 187   | 237   |
| c. | Yield force at 0.2% offset, kips           | 150.0 | 190.0 |
| d. | Elongation in 20 bar dia. gauge length (%) | 4     | 4     |
| e. | Nominal cross-sectional area, sq. in.      | 1.245 | 1.577 |
| f. | Nominal bar weight, lbs/ft                 | 4.39  | 5.56  |
| g. | Weight of zinc coating, oz/sq. ft.         | 0.85  | 0.85  |
| h. | Carbon content, % max                      | 0.55  | 0.55  |

0. **C. Ducts for Vertical Tendons:**

1. Duct enclosures for vertical prestressing steel shall be standard PVC pipe class 200 unless otherwise indicated.
2. All ducts shall be provided with expendable valves to facilitate the injection of epoxy after prestressing.
3. All connection details shall be as shown on the shop drawings.

**D. Epoxy Grout for Vertical Tendons:**

1. The tendon system shall incorporate complete two component epoxy protection of the prestressing steel inside ducting and anchors. Epoxy grout shall comply with the requirements of Section 03315.
2. Portland cement grout will not be accepted.
3. Epoxy grout shall be a 100% solids, two-component, water-insensitive resin system, specifically for injection applications.

**E. Earthquake Cables Assemblies:**

1. Earthquake cables shall consist of seven-wire galvanized strand as indicated in subparagraph 2.3A and shall be installed to connect wall and wall footing.
2. Closed cell neoprene sleeves for earthquake cables, which encase the galvanized strands, shall be designed to permit unrestrained flexing of the strands inside the sleeves under the maximum projected radial wall movement.
3. Material of the sleeves shall be medium grade closed cell neoprene conforming to ASTM D1056, Grade 2C3E1. Rubatex R423N, or equal, is an acceptable material.

F. **Portland Cement:** Portland cement for the tank construction and shotcreting shall meet the requirements set out in Section 03300 of these Specifications.

G. **Shotcrete:**

1. Fine aggregates:

- a. Fine aggregates shall meet the requirements of Section 03300.
- b. A well graded coarse sand shall be used for all shotcrete applications.
- c. Coarse sand shall meet the following gradation:

| <u>Sieve Size</u> | <u>% Passing by Weight</u> |
|-------------------|----------------------------|
| 3/8-inch          | 100                        |
| No. 4             | 95 - 100                   |
| No. 8             | 80 - 100                   |
| No. 16            | 50 - 85                    |
| No. 30            | 25 - 60                    |
| No. 50            | 10 - 30                    |
| No. 100           | 2 - 10                     |

The fineness modules shall fall between 2.70 and 3.00.

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NTS: Include the following subparagraph "d" only if smooth finish (as opposed to natural gun finish) is required for tank wall.

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d. Plaster sand shall meet the following gradation:

| <u>Sieve Size</u> | <u>% Passing by Weight</u> |
|-------------------|----------------------------|
| 3/8-inch          | 100                        |
| No. 4             | 97 - 100                   |
| No. 8             | 90 - 98                    |
| No. 16            | 70 - 85                    |
| No. 30            | 35 - 55                    |
| No. 50            | 15 - 25                    |
| No. 100           | 2 - 8                      |

The fineness modules shall fall between 2.40 and 2.75.

2. Rebound:

- a. Rebound materials shall not be reused in any form for shotcrete.

3. Water: Water shall meet the requirements of Section 03300.

4. Air-Entrainment and Admixtures: Air-entrainment and admixtures shall meet the requirements of Section 03300.

5. Shotcrete Proportioning:

- a. Each one cubic yard of mortar in the ready mix truck of mixer shall consist of a minimum of 1 part of portland cement to 3 parts of moist sand. Up to 50 oz. of set retarding admixture may be added at the option of the CONTRACTOR during warm weather conditions. Each cubic yard of mortar shall contain 0.1 percent by volume (or 1½ pounds per cubic yard) of polypropylene fibers.
  - b. Additives other than those specified herein (such as POZZOLITH 300 N or others) shall not be used unless specifically approved by the CONSTRUCTION MANAGER.
  - c. Unless otherwise indicated, shotcrete cylinder strengths at 28 days shall not be less than 4,000 psi.
  - d. Higher shotcrete cylinder strengths shall not permit a reduction in the above specified cement contents.
  - e. The cement content in the above mix designs shall be increased should the specified 28 day strength requirement not be met.
6. Fibrous Shotcrete Reinforcement
- a. All shotcrete, unless otherwise specified herein, shall be fibrous reinforced . Such material shall consist of 100 percent virgin polypropylene fibrillated fibers specifically manufactured for use as concrete/shotcrete secondary reinforcement. The required volume of fibers added per cubic yard of shotcrete shall be as specified herein.
  - b. Polypropylene fibers will provide greater control of cracking from drying shrinkage and thermal expansion/contraction, reduction of permeability, an increased impact capacity, an improved shatter/abrasion resistance and added toughness of the shotcrete.
  - c. The fibers shall be manufactured in accordance with applicable building codes and ASTM C 1116 Type III 4.1.3 (Ref. ASTM C 1018). Fibrous concrete reinforcement shall be manufactured by FIBERMESH Company, Chattanooga, Tennessee, or equal.
  - d. Acceptable polypropylene fibers shall have the following physical characteristics:
    1. Specific gravity = 0.91
    2. Tensile strength = 80 - 110 ksi
    3. Fiber length = graded by manufacturer
  - e. The polypropylene fibers and admixtures shall be added to the shotcrete at the time it is batched and in the amounts as required herein. Such additives shall be mixed in strict conformance with the manufacturer's instructions and recommendations for uniform and complete distribution. Each certificate of delivery supplied by the shotcrete supplier shall indicate the additive trade name, manufacturer's name, and amount per cubic yard added to each batch of shotcrete.

## H. CURING MATERIALS

1. **Curing Compound:** Curing compounds shall be the following or equal:

- "MB 429" by Masterbuilders
- "Clear ARB" by Hunt Process Company
- "Select Cure CRB" and "Select Cure Seal AC-309" by Select Products Company
- "American 309 Acrylic Sealer" by American Concrete Systems

2. **Evaporation Retardant:** Evaporation retardant shall be "Confilm" by Masterbuilders or equal.

I. Taper Ties

1. Tank corewalls shall be formed by utilizing taper ties with plastic rubber plugs of an approved and proven design. The plugs must be driven into the hole with a steel rod, placed in a cylindrical recess made in the plug. At no time shall plugs be driven on the flat area outside the cylindrical recess. Plugs shall be A-58 SURE PLUG as manufactured by Dayton Superior, Santa Fe Springs, CA , or equal.

2.4 TANK ACCESSORIES AND EMBED

- A. All tank accessories, wall pipes, sleeves, openings, hatches, etc., shall be provided at the locations, elevations, and orientation shown in the Contract Drawings including all addenda. Spacing of vertical tendons, mild steel reinforcement, and circumferential prestress shall be made to accommodate all such openings. Additional reinforcement shall be provided around openings in accordance with standard details. All tank accessories embedded in concrete walls, floor and roof shall be fabricated of Type 316 stainless steel, unless otherwise specified.

2.5 MANUFACTURERS

- A. Products shall be of the following manufacture and type or equal:

1. Neoprene sleeves for earthquake cables:

Rubatex, R431N or R423N

2. Set-retarding admixture:

Masterbuilder's "Pozzolith 300R"  
Prokrete's "Prokrete-R"

**PART 3 -- EXECUTION**

3.1 GENERAL

- A. The CONTRACTOR shall provide a prestressed concrete tank of the dimensions indicated, consisting of a concrete roof, concrete floor and a cast-in-place concrete core wall, reinforced vertically with post tensioning bars and circumferentially with wrapped strand and protected with several coatings of pneumatically placed concrete [and paint].
- B. The tank shall conform to the dimensions and be equipped with the appurtenances indicated.
- C. Cast-in-place concrete work shall conform to the provisions of Section 03300 as supplemented and modified by this Section.

- D. Pouring of tank corewalls shall be done only through pouring openings on one of the wall sides, and may not be pumped or poured from the top through the use of “elephant trunk” or tremies. CONTRACTOR shall erect the complete form on both sides of the wall and then remove form panels for pour openings from either the inside or outside form assembly before concrete pouring starts. The horizontal centerline distance between the nearest opening and the bulkhead for the vertical joint shall not exceed 36 inches. The vertical centerline between the horizontal rows of openings shall not exceed 96 inches. The minimum pouring opening size shall be 18" x 18". The bottom of the lower openings shall be no more than 48 inches from the top of the wall-footing. Under no circumstances shall forming be such that the drop of concrete in the forms will exceed 8 feet in any one place.
- E. Forms may be removed as soon as the concrete has developed sufficient strength to prevent sagging, excess deflection, misalignment, spalling, cracking, breaking of edges and surfaces and any other damage to the concrete. Removal of wall forms shall not be started any sooner than 12 hours after completion of the wall pour.
- F. Concrete in circular spirally-tied columns, having no horizontal reinforcement crossing into the region bounded by the vertical reinforcement, may be deposited from the top of the column form, at the CONTRACTOR's option. All concrete shall be vibrated as required in subsection 3.6 of Section 03300. The final quality of the poured concrete column shall be the responsibility of the CONTRACTOR. If the quality of the column is found to be unacceptable, the CONSTRUCTION MANAGER, at the CONTRACTOR's expense, may require the complete removal of the column and may require that an alternate placement method be used.
- G. Do not apply vertical or horizontal prestressing to tank until core has obtained the specified 28-day strength, as determined by test cylinders.
- H. Inspect surfaces of core wall at patching work. Test patches for chlorides and other chemicals that cause corrosion of prestressing. If corrosive patching material is found remove any patching materials containing corrosive chemicals prior to sandblasting and then patch wall and build out to a uniform circular surface all around. Sandblasting the entire surface of these patches and the core wall surfaces prior to applying more shotcrete or prestressing.
- I. **Grout at Base of Cast-in-Place Prestressed Wall:**
  - 1. Place layer of cement or sand-cement grout, which is approximately 2 inches deep above the bearing pad at base of vertical wall of reservoir.
  - 2. Use a special measuring device for grout so exact amount can be placed in each section of wall. Obtain approval of method and measurement system prior to day of wall pour.
  - 3. Deposit concrete as quickly as possible after grout is placed.
  - 4. Vibrate to mix grout and concrete.
- J. **Curing of Prestressed Concrete Tank:**
  - 1. Keep horizontal concrete surface continuously wet for 7 days where normal portland cement is used , or 3 days where high-early strength cement is used, by use of a waterproof barrier (i.e., **Visqueen**) placed over the horizontal surface.

2. Begin curing immediately after initial concrete set has occurred.
3. Do not allow alternate wetting and drying of concrete surfaces during curing period.
4. Curing compounds may be used for vertical formed surfaces. Curing compounds may be used on horizontal concrete surfaces in addition to the wet cure specified above.

### 3.2 CIRCUMFERENTIAL PRESTRESSING EQUIPMENT

- A. The circumferential stressing system shall produce a continuously, electronically (or substantial equivalent) monitored permanent stress or force recording on a graph paper along the full length of the strand as it is being applied and the stress variation in any strand at any point around the circumference shall not be greater than plus 1.5 percent of the ultimate strength of the steel. In addition to this recording, any system which deflects the tensioned strand between the tensioning device, shall produce a similar continuously monitored stress or force record along the full length of the strand as it is being applied to the wall. These recordings shall show that either before or after deflection, the stress variation in any strand at any point around the circumference shall not be greater than 1.5 percent of the ultimate strength of the steel. Manually recorded force readings shall not be accepted.
- B. All continuous force readings for the circumferential prestressing operations shall be developed with electronic (or the substantial equivalent) force (strain gauge method) sensing transducers, all having a maximum nonlinearity error of plus or minus 0.5 percent and a maximum hysteresis error of plus or minus 0.25 percent.
- C. Any wrapping that does not meet the indicated stress tolerances or cannot meet the requirements will not be accepted.
- D. Since intermittent force applications can result in an unequal stress distribution around the wall (due to friction losses), the prestressing system shall be capable of applying a continuous wrapped force at any point around the circumference within the specified tolerances. Circumferential stressing systems based on jack-operated cable or rod-type tendons will not be allowed.
- E. Before any stressing operation may be started, CONTRACTOR shall calibrate all recording equipment at a qualified testing laboratory as indicated in Paragraph 1.9.

### 3.3 CIRCUMFERENTIAL PRESTRESSING APPLICATION

- A. Wrapped strand shall be anchored to the wall at least once for every coil or reel.
- B. Permanently anchoring one strand to a previously wrapped strand shall not be permitted.
- C. Wrapped strand ends shall be jointed by suitable splicing methods that will develop 90 percent of the full strength of the strand.
- D. Use of different alloys in the splicing material shall not be permitted.
- E. The clear spacing between any two wrapped strands in the vertical direction shall be 1.5 strand diameters or 3/8-inch, whichever is larger.
- F. Any wrapped strands not meeting the spacing requirements shall be spread by approved methods or must otherwise be removed.

### 3.4 CIRCUMFERENTIAL PRESTRESSING OPERATIONS

- A. The average electronically (or substantial equivalent) recorded steel stress shall be 70 percent of the guaranteed minimum ultimate strength (MUS) of the steel at any time during and after stressing.
- B. Recordings of the prestressing force must be based on a continuous sensing of the applied force on the strand between the tensioning drum and the wall when, and as, the strand is being wrapped and laid on the wall.
- C. The force setting on wrapping machinery shall be such that the applied forces fall within the specified minimum or maximum stress or force limitations; the force setting shall be corrected immediately when the applied force falls outside the required force tolerance limitations.
- D. In the event that the stressing machinery is incapable of holding the applied forces within the specified stress or force limitations, CONTRACTOR shall remove and replace such machinery with proper machinery capable of meeting these requirements.
- E. The final prestressing force shall be no less than the required force per subsection 2.2B.
- F. Manual, individual or intermittent force readings taken on wrapped strand in fully bodily contact with the wall will not be accepted. Force readings based on anything other than instantaneous force readings, as the strand is being tensioned, and wrapped around the tank will not be accepted.
- G. Wrapping may start when the concrete has reached a strength of 3,000 psi. All exterior surfaces of corewall shall be shot-blasted prior to wrapping.
- H. In the event that gaps between the corewall and the wrapped strand develop that exceed 3/8 inch, wrapping shall be discontinued and the wall shall be built up with shotcrete to provide the proper curvature. Alternately, if approved by the CONSTRUCTION MANAGER, the gaps may be dry-packed after wrapping is completed and before shotcreting is started.
- I. Wrapping over intermediate shotcrete coats or built-up shotcrete areas may commence 12 hours after the shotcrete has been applied or when the shotcrete has reached a strength of 250 psi, whichever is later.
- J. The temperature of the prestressed material during application shall not be allowed to increase by more than 50 degrees due to the stressing technique at any time during such application. No system which relies on pulling the prestressing material through a die to create a force will be allowed.
- K. All anchors for circumferential prestressing shall be dry packed or pressure grouted with cement grout or an approved two component epoxy at the CONTRACTOR'S option.
- L. Grout injection pipes shall be fitted with positive mechanical shutoff valves which shall not be removed within the first 24 hours after grouting.
- M. Grouting of anchors shall be started at the lowest grout connection.
- N. Shot-blast exterior surfaces of core wall, after inspecting any patches for corrosive chemicals, to remove traces of original surface smoothness and original surface color, form oil, and laitance.



- O. Complete shot-blasting prior to application of horizontal prestressing.
- P. Shot-blast far enough in advance of prestressing operation so as not to interfere with other operations.
- Q. Leave wall clean, heavily pitted, and generally uniform in appearance.
- R. Shotcrete a uniform 3/8-inch layer all around over this sandblasted surface prior to applying the initial horizontal prestressing. Provide proper curvature to receive wrapping where required.
- S. The Tank Subcontractor shall utilize a self-contained mechanical etching or shot-blasting system, combined with a vacuum recovery system, to prepare the exterior surface of the tank corewall for strand wrapping and shotcreting. Systems which rely on sandblasting or steel shot without a vacuum recovery system shall not be allowed.

### 3.5 VERTICAL PRESTRESSING

#### A. **Anchorage for Vertical Post-Tensioned Tendons:**

1. All post-tensioned prestressing shall be secured at the ends by means of approved, permanent, hot-dipped galvanized or zinc plated anchoring devices, which shall hold the prestressing steel at a force not less than 90 percent of the guaranteed minimum tensile strength of the prestressing steel.
2. The load from the vertical prestressing anchoring device shall be distributed to the concrete through steel bearing plates as indicated. Provide initial lock-off prestress force of 75% of guaranteed ultimate tensile strength of the thread bars.
3. All vertical prestressing anchor plate dimensions, all dimensions relating to the conical hole in the top and bottom of the bearing plate (35 degree cone angle with the vertical), all steel tubing attached to the top bearing plate, and all tendon spacing shall strictly conform to approved shop drawings.
4. Fully-threaded anchor connections shall be used at both ends of the vertical prestressing bar, which shall incorporate a spherical-shaped bearing surface to match the conical surface in the bearing plate.
5. The contact point of the spherical-shaped vertical prestressing bearing surface to conical hole shall be approximately 1/4-inch to 1/2-inch below the bearing plate surface.
6. Wedge anchors shall not be used for permanent anchor hardware.

#### B. **Duct Installation:**

1. Duct enclosures for prestressing steel shall be accurately placed at the locations shown on the shop drawings and shall be securely fastened in place to prevent movement.
2. All vertical tendon ducts shall be flushed with water immediately upon completion of the concrete vibrating operation after each lift of concrete. This procedure shall continue until pouring and vibrating of concrete around the tendons has been completed. Water shall be introduced at the top of the wall and be permitted to drain through the bottom grout tube. Upon completion of the water flushing operation of the

tendons, the ducts shall be given a short burst of compressed air to remove any accumulations of water in the ducts.

3. Cleaning of tendon ducts with air only shall not be allowed.
4. Placing of pressure grouted tendon ducts shall be done to proper locations, elevations and alignments, with a maximum tolerance of plus or minus 1/4-inch. All tendons shall be properly tied at the anchor plates and shall be tied and supported at no more than 4-foot intervals between anchor plates.
5. Bearing plates must be installed at right angles to the required alignment of the prestressing tendon near the anchors. The maximum permissible misalignment is 2.5 degrees plus or minus.

**C. Placing Prestressing:**

1. Duct enclosures for vertical prestressing units shall be accurately placed at the locations shown on the shop drawings and shall be securely fastened in place to prevent movement.
2. After installation, the ends of ducts shall at all times be covered as necessary to prevent the entry of water or debris.
3. A 1/2-inch diameter grout tube connection and valves shall be provided at the bottom of the vertical prestressing unit. Another tube of 3/8-inch minimum diameter shall be provided at the top of each unit or an equivalent venting hole shall be provided in the top anchor plate.
4. No vertical stressing system shall be employed which is incapable of producing a continuously monitored permanent force-elongation record from zero to full force and to final lock-off. Manual methods of force and elongation monitoring shall not be allowed. .
5. Stressing shall not start until tests on the concrete samples placed and cured under the same conditions as of the wall indicate that the core wall has attained the design compressive strength.
6. Prestressing of vertical unit shall be applied by putting all units under full design load before horizontal prestressing is commenced.
7. Prior to post-tensioning any vertical tendon, the CONTRACTOR shall demonstrate to the CONSTRUCTION MANAGER that the prestressing steel is free and unbonded in the duct.

**D. Grouting of Vertical Prestressing Ducts:**

1. After the vertical bars have been stressed to the required tension, each conduit shall be flushed out with clean water and then blown out with compressed air. The conduit shall then be completely filled with grout. Grout shall consist of a two component water insensitive epoxy.
2. The 3/8-inch diameter grout tube extension at the top shall be provided with a valve. Grouting shall be done from the bottom upwards. As soon as the grout runs out of the top extension tube, the valve shall be closed and the pressure built up to not less than

50 pounds per square inch and maintained until the grout has set. After a short interval, the level in the extension tube shall be checked by sticking a wire into the extension tube. If the grout level has dropped in the tube, the grouting shall be repeated and the level tested until grout remains steady at the same level in the extension tube. After this steady state has been obtained, the grout machine shall be connected to the extension tube and pressure applied to assure that the extension tube is not blocked. The grout tubes projecting through the core wall shall not be removed earlier than the day following the grouting operation. Following removal of the grout tubes, the resulting holes in the wall shall be filled with sealant. Alternatively, the CONTRACTOR may utilize a hole in the top bearing plate in lieu of the grout tube extension described above.

3. Upon completion on pressure grouting of the ducts, the CONTRACTOR shall fill the anchor pockets with non-shrink grout and the surface shall be finished flush and given a steel trowel finish.

### 3.6 EARTHQUAKE CABLE ASSEMBLY INSTALLATION

- A. The cables may be cut to length with a burning torch.
- B. Where necessary, the strands shall be pre-bent before placing the units in wall and wall footings.
- C. The strands shall be tied to the lower horizontal circumferential tie-bar on the vertical prestress tendons.
- D. In the footing, the strands shall be tied to the radial footing bars.

### 3.7 TOP AND BASE JOINT INSTALLATION

#### A. **PVC Waterstop:**

1. PVC waterstop shall be continuous, where shown, and as specified in Section 03290.
2. In base slab joints, field bond to the wall base joint waterstop to form a continuous barrier capable of withstanding water pressure.
3. In vertical wall joints, field bond to the PVC waterstop in the base joint.

#### 4. **Installation in Footings:**

- a. Form footing in such a manner that base of wall joint waterstop will be continuously supported as concrete is placed.
- b. Position base of wall hollow-bulb section accurately, vertically, and horizontally to a location tolerance  $\pm 1/4$  inch.
- c. Field measure location of waterstop at base of wall using radial measurements from reservoir center to guarantee waterstop is located and placed in a true circle over its entire length.
- d. Furnish and install a continuous circular form on both sides of the waterstop to secure the 9-inch waterstop to ensure proper final shape and position.

- e. Carefully screed and trowel finish concrete surface within area to be occupied by the wall to provide a uniform bearing surface for neoprene and spong rubber pads.
- f. Grind or repair any surface irregularities which, in the opinion of the CONSTRUCTION MANAGER, may interfere with the proper action of joint.
- g. Prepared Surface Tolerance: Not exceeding 1/8 inch in 10 feet.
- h. Provide an approved means to ensure support of the projecting half of the water stop as the wall concrete is placed, to prevent out-of-tolerance movement and location due to concrete pressure or other construction loads which might be placed on the waterstop.

**B. Neoprene Pad:**

1. Position for wall base joint and top joint as shown.
2. Dry concrete surface and brush thoroughly to remove dirt and foreign material prior to cementing neoprene pad in place.
3. Use waterproof rubber cement or glue that will not damage pad to bond the neoprene to the concrete surface.

**C. Sponge Rubber Pad:**

1. Place as shown to preclude concrete-to-concrete bearing between wall and base slab and between wall and the roof slab.
2. Prepare concrete surface and cement sponge rubber pad as specified for paragraph 3.7 B "Neoprene Pad" above.
3. Caulk crevices in the trimmed sponge rubber with specified caulking compound.
4. Support all edges of sponge rubber pieces and strips.
  - a. To restrain all surfaces from movement during concrete placement.
  - b. To reduce load deflection of the sponge rubber under the weight of fresh concrete to a minimum.
5. Protect during initial concrete placement to prevent movement of sponge rubber pad from vibration, falling concrete, or other forces.
6. Perform the following after concrete placement:
  - a. Inspect base joint and top joint prior to horizontal prestressing or filling of the tank.
  - b. Clean joint of any concrete or mortar so sponge rubber can be seen full depth and so joint is free from concrete or other material that would restrict or prevent wall movement.
  - c. Repair any damage due to poor joint workmanship.



1. Shotcrete shall be applied in a steady, uninterrupted flow.
2. Should the flow become intermittent for any cause, the machine operator shall direct the nozzle away from the work until it again becomes constant, or shut off the flow of materials.

**B. Position of Pneumatic Nozzles:** The nozzle shall be held at approximately right angles to the surface and shall be kept at the proper and the same distance from the surface dictated by good practice standards for the type of application, type of nozzle, and air pressure employed.

**C. Shotcreting More Than One Layer:**

1. Sufficient time shall be allowed for each layer of shotcrete to set so it may take the next layer without sagging.
2. The shotcrete shall be started at the bottom of the wall until the wrapped strand has been covered. Subsequent shotcrete layers may be applied from the top down or from the bottom up at the discretion of the Tank Subcontractor.
3. While the nozzle travels around the wall, the nozzle shall be raised or lowered at the uniform rate in such a manner that an adequate overlapping of coatings and a uniform finish will develop.
4. The nozzle shall be spiraled up or down around the tank to either the top or the bottom of the wall or to the termination of the intermediate strand layer.

**D. Application of Shotcrete:**

1. Slump of mortar at the pump shall be such as to ensure proper penetration around the strand and proper conveyance of the material through the hose.
2. Walls shall not be prewetted prior to the shotcrete application.
3. Each layer of shotcrete shall be completed for the full circumference of the tank and substantially the full height of that layer before the next layer of shotcrete may be applied. A minimum of 3/8-inch shotcrete shall be applied to the entire exterior blasted corewall surface prior to applying the machine strand wrapping.
4. All shotcrete coatings shall be built up in layers of approximately 3/8-inch in thickness until the required thickness has been obtained.
5. Each layer of wrapped prestressing steel shall be covered with shotcrete until a minimum cover of 3/8-inch over the steel has been obtained.
6. The final covercoat shall be applied in at least 3 layers of equal thickness to make up the full thickness of shotcrete 1-1/2 inches or more over the outermost strand layer.
7. All shotcrete shall be fibrous reinforced. Such material shall consist of 100% virgin polypropylene as specified in subsection 2.3 G.6.

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NTS: Include the following subparagraph E only if a smooth float finish is required.

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1. Outlet pipes, including the overflow pipe, shall be plugged.
2. The tank shall be filled with water to 1 foot above the overflow level. Use of either nonpotable water or plant effluent is acceptable.
3. If leakage exceeds the indicated amount, the tank shall be emptied and repaired and the test repeated.

\*\* END OF SECTION \*\*



CERTIFICATION OF DESIGN

Re: Contract Between:

OWNER: \_\_\_\_\_  
(Name)

and

CONTRACTOR: \_\_\_\_\_  
(Name)

on

CONTRACT: \_\_\_\_\_  
(Number)

Date: \_\_\_\_\_

Title: \_\_\_\_\_

CONTRACTOR hereby certifies that \_\_\_\_\_

1. Is licensed or registered to perform professional work in the State of California,
2. Is qualified to design the Prestressed Circular Tanks specified in Section 03240 of subject contract,
3. Has designed \_\_\_\_\_ before,  
(List tanks, location, and contracts)
4. Has prepared the design in full compliance with the applications and requirements of Section 03240 of subject contract including all applicable laws, regulations, rules, and codes, and
5. Has been employed full-time by the approved tank Subcontractor,
6. Meets all of the experience requirements of Section 03240,
7. The work has been signed and sealed pursuant to applicable state law.

FOR: \_\_\_\_\_  
(CONTRACTOR)

BY: \_\_\_\_\_  
(Signature)

\_\_\_\_\_  
(Name and Title)

DATE: \_\_\_\_\_