SECTION SP-27 – RESERVOIR CONCRETE WORK

27.01 GENERAL

A. DESCRIPTION: This item of work consists of furnishing of labor, tools, equipment, and materials necessary to complete this item of work, in place complete, as shown on the plans and as specified in DIVISION 300 - CONSTUCTION, Section 303.03 CONCRETE WORK, of the Water System Standards, 2002, and as amended hereinafter as they apply to this project for the construction of the concrete reservoir, both conventionally reinforced and prestressed alternatives where provisions apply.

B. RELATED WORK: Related work specified in other sections:

Section 303.03 (WSS)	Concrete Work
Section SP-10	Hot Weather Concreting Procedures

C. SUBMITTAL:

(1) All false work and forming requirements for roof support systems must be designed by an engineer registered in the State of Hawaii. The drawings, with supporting calculations, must each be signed and sealed by the engineer. No work shall be started until the roof support system and form design has been submitted. The false work design engineer must visit the site and approve the erection of all shoring prior to the placement of any concrete.

(2) The Contractor shall be solely responsible for the adequacy of the forming, shoring and bracing design.

(3) Any form work installed by the Contractor shall be solely at the Contractor's risk. Submittal to the design engineer will not lessen or diminish the Contractor's liability.

(4) Cement: The cement company shall provide certified mill certificates with every shipment, giving proof that the cement to be supplied is in compliance with ASTM C 595, Type 1L.

(5) Concrete mix design for each class of concrete proposed to be used. Mix design shall list quantities to be used for a cubic yard of concrete. List all admixtures and proposed quantity to be used for each admixture. Specify range of slump and water-cement ratio. List sources of aggregates to be used and provide sieve analysis of each aggregate demonstrating compliance with Water System Standards gradations listed in Table 300-7 and 300-8.

(6) Provide product data sheets for manufactured items showing conformance to product properties or ASTM conformance, handling and storage requirements, installation instructions and limitations as applicable.

27.02 CONCRETE CLASSES:

A. DWS 4000 (fc = 4,500 psi min.) – Reservoir wall concrete, and for items specifically noted on Drawings. The maximum water-cement ratio shall be 0.42. All concrete used in this class concrete shall include a crystalline waterproofing admixture.

B. DWS 4000 - Reservoir columns, roof slab, floor slab, foundation, pipe jackets, and all building concrete, and for items specifically noted on Drawings. The maximum water-cement ratio shall be 0.42. All concrete used in this class concrete shall include a crystalline waterproofing admixture.

C. DWS 2500 - All other concrete where strength is not indicated or shown, it shall be minimum 2,500 psi at 28 days.

27.03 CONCRETE ADMIXTURES

Admixtures shall subject to approval by the Department of Water.

A. Water reducing admixtures shall conform to ASTM C494, Type A.

B. Retarding admixture shall conform to ASTM C494, Type B.

C. High-range, water reducing admixture (superplasticizer) shall conform to ASTM C494, Type F

D. Crystalline waterproofing admixture shall be designed to be added during concrete batching, reacting with moisture in fresh concrete and by-products of cement hydration to cause a catalytic reaction that generates a non-soluble crystalline formation throughout the pores and capillary tracts of the concrete permanently sealing the concrete.

Example of products meeting the above requirements are:

(1) Xypex E-Series Admixture – select the product appropriate for project conditions (C-500/C-500 NF, C-1000/C-1000 NF, C-2000)

(2) Aquafin-IC Admix

(3) Krystol - KIM

(4) Approved equal

E. Shrinkage-Reducing Admixture shall be designed to reduce capillary tension of pore water in the concrete. Products designed to induce compressive stresses into the concrete to offset tensile stresses caused by drying shrinkage will not be permitted.

Example of products meeting the above requirements are:

(1) BASF Tetraguard AS20

(2) Grace Eclipse Floor 200

(3) Approved equal (superplasticizer) shall conform to ASTM C494, Type F

27.04 PROPORTIONING

A. In addition to the requirements for "Proportioning Concrete Mix" specified in Section 303.03.C of the Water Systems Standards, the concrete mix design for elements of the concrete reservoir shall have a maximum water-cement ratio as stated in this SP-Section.

B. Shrinkage-Reducing Admixture

(1) It is the responsibility of the contractor to verify admixtures used are compatible and will not result in undesirable properties in the concrete. Trial batches will be required to assure compatibility if manufacturers will not provide written confirmation of admixture compatibility.
(2) The prestressing concrete reservoir contractor has the option of including a shrinkage-reducing admixture to the reservoir concrete mix design in order to reduce the possibility of shrinkage cracks forming in reservoir concrete.
(3) For the conventional reinforced concrete reservoir, the concrete requires the shrinkage-reducing admixture to be included for the entire structure.

27.05 EPOXY ADHESIVE:

Epoxy Adhesive shall be two-component, injectable, meeting the requirements of ASTM C881, Type IV, Grade 3. The adhesive product shall have a current ICBO or ICC ES Report permitting the use of the product in uncracked and cracked hard rock concrete with reinforcing steel dowels, such as Hilti 'HIT-RE 500-SD Injectable Mortar' or Simpson 'SET-XP Adhesive' or approved equal.

27.06 HOT WEATHER CONCRETING:

See SP-10A HOT CONCRETING PROCEDURES

27.07 FIELD TESTS

A. Replace the third paragraph in Section 303.03.L, "Field Tests of Concrete" with the following:

Five cylinder samples, 6"x12", shall be taken for each class of concrete poured each day and for every 50 cubic yards of each class or fraction thereof. Two (2) cylinders shall be tested at age of seven (7) days and twenty-eight (28) days in accordance with ASTM C39, "Standard Method of Test for Compressive Strength of Cylindrical Concrete Specimens". The last sample shall be held in reserve for use to verify suspect test results or a spoiled test sample.

B. Slump tests shall be conducted on each ready-mix concrete truck discharging on-site for project site, with the exception of concrete used for thrust blocks.

27.08 FORM WORK

A. General

Forms shall be so constructed that they can be removed without hammering on, or prying against, the concrete and shall be removed in such a manner as to prevent damage to the concrete and to ensure the complete safety of all parts of the structure. Forms previously used shall be thoroughly cleaned of all dirt, mortar and foreign matter before being reused.

B. Reservoir Form Work:

(1) All vertical wall and column footing sides shall be formed by methods acceptable to the Department of Water and the design engineer and to the correct elevations and location shown on the Drawings.

(2) The wall form design shall be such that wall sections shall be poured for the full wall height without any horizontal construction joints and without causing snapping of form ties which shall be of sufficient strength and number to prevent spreading of the forms during the placement of concrete and which shall permit ready removal of the forms without spalling or damaging the concrete.

(3) Taper ties with plastic or rubber plugs of an approved and proven design may also be used for form ties. The plugs must be driven into the hole with a steel rod, placed in a cylindrical recess made therefore

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, Miamisburg, OH (phone: (800) 745-3700, www.daytonsuperior.com) or approved equal.

(4) The BURKE, ECONOMY, SYMONS, ALUMA, and regular plywood forms may be used for forming of circular walls.

(5) Unless specified on the Drawings, no chamfer strips shall be placed at the horizontal construction joint forms for reservoir walls.

(6) The height of such wall panel forms shall not exceed 8 feet unless built-in pouring openings are incorporated in such wall panels. In this case, pouring of walls shall be done only through pouring openings on one of the wall sides, and may not be pumped or poured from the top using "elephant trunks" or tremies.

(7) The pour openings shall be no smaller than 2-foot square, and spacing either vertically or horizontally no more than 6 feet. The vertical distance between rows or floor slab shall be no higher than 4 feet.

(8) Forms and falsework supports for the roof shall be sufficiently rigid and strong to support the wet concrete and the workers and equipment necessary for its placement without appreciable deflections. A minimum of 40 PSF for live load shall be allowed in the falsework design.

(9) The Contractor shall provide either wedges under timber posts, screw jacks under shoring, or other means to adjust the forms and relieve the load.

(10) Unless the level of roof screeds remains unaffected by the deflection of roof-forms, an upward camber, where necessary in the opinion of the Department of Water, shall be provided to all form areas which will deflect under the concrete load.

(11) The Contractor shall determine if additional camber is required for the roof slab form to permit concrete and steel to act efficiently without development of deflection cracks.

C. Form Work Tolerances:

(1) Wall form sills shall be used to contain or hold down neoprene pads and facilitate proper alignment of forms. The maximum permissible variation in the horizontal and vertical location of the waterstops, neoprene pads and seismic cables is plus or minus 1/4 of an inch.

(2) The maximum permissible variation in tank radius, as measured from the center of the tank to the inside wall surface at the bottom, is plus or minus 3/8 of an inch.

(3) Out-of-round tolerance: 3/4" in 50 feet, 3/8" in 10 feet and 3/16" in 2 feet from the true curvature specified at any point on the wall.

(4) The maximum permissible variation in the vertical alignment, from the bottom to the top of the wall, in plus or minus 3/8 of an inch.

(5) The permitted tolerance of the average wall thickness for poured walls shall not vary more than 1/8 inch either way. All transitions from plus to minus shall be more gradual, even and smooth, and without abrupt changes in the surfaces.

(6) Unless stated otherwise on the Drawings, the permissible tolerance at any point for flat roof form-surfaces shall not exceed plus or minus 1/4 inch from the specified elevation or thickness. The finished roof surface shall be capable of draining completely. Contractor shall camber or provide necessary forming supports to prevent low spots when forms are filled with concrete and to insure drainage. If low spots should occur, Contractor shall submit a corrective procedure to the Department of Water for approval.

(7) Slab screeds and bulkheads shall be set to specified alignment and elevations permitting a maximum tolerance of 1/4 inch plus or minus.

(8) Any transition between high and low points of the finished roof slab shall be gradual, smooth and even, and shall be to the satisfaction of the Department of Water.

(9) Adequate time and cooperation shall be provided to the BWS Construction Inspector and design engineer to verify the compliance of these requirements prior to closing up the forms or pouring concrete.

27.09 FORM WORK REMOVAL:

The following shall replace the items stated in table on WSS Section 303.O.3 (Page 303-16) only for specific items described:

A. Removal of wall and column forms shall not be started any sooner than 12 hours of accumulated time with the ambient air temperature above 50 degrees F after completion of the wall or column pour, respectively.

B. Wall and column forms may be removed when the concrete has developed a

minimum compressive strength of 1,200 psi to prevent sagging, excess deflection, misalignment, spalling, cracking, breaking of edges and surfaces and any other damage to the concrete. The contractor shall put the specified concrete curing system in place for the period specified in WSS Table 300-10

C. Removal of roof forms will be permitted only when the concrete has attained the compressive strength equal to the required 28-day compressive strength specified in these Special Provisions or shown on the Drawings, but no earlier than 7 days regardless of the concrete compressive strength.

Add following items to the end of Section 303.03.O.3, "Form Removal:

D. Contractor shall remove all wood splinters on concrete surfaces after stripping of wood forms.

27.10 CONVEYING, PLACING AND HANDLING:

Add the items below the end of Section 303.03.P, "Conveying, Placing and Handling":

A. Concrete in columns, having no horizontal reinforcement crossing into the region bound by the vertical reinforcement, may be deposited from the top of the column form, at Contractor's option such that no separation of the coarse aggregate from the mortar takes place. All concrete shall be vibrated as required here-in. 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 Department of Water, at the Contractor's expense, may require the complete removal of the column and may require that an alternate placement method be used.

B. Each layer of concrete in walls and columns shall be vibrated thoroughly before the next layer may be placed thereon. Vibrators shall be taken through the top layer down through the full layer thickness below to ensure proper integration of the concrete and to avoid the development of cold joints and honeycomb between the layers. In other words, each layer of concrete shall be vibrated at least twice.

C. Horizontal waterstops in floor and roof decks, if shown on the Drawings, shall be lifted up, then the concrete is placed under these waterstop(s), the waterstop shall then be laid down on that concrete, additional concrete shall be placed on top of that waterstop to the approximate finish level of the concrete, where upon the concrete shall be thoroughly vibrated in one continuous motion from one end of the waterstop to the other end without skipping any areas. Visual observation shall be performed by the Contractor to certify that voids under waterstops have been eliminated.

D. Cold joints between form bulkheads in floor, roof slabs and in wall footings shall be avoided at all costs. Joints shall be continuously covered with new concrete, and shall be thoroughly integrated through vibration, even if it means that horizontal passes of only 6 inches in width be made until additional concrete and equipment becomes available to permit wider passes in concrete placement.

E. Protect concrete placed immediately before rain to prevent rainwater from coming in contact with it. Keep sufficient protective covering on hand at all times for this purpose.

F. Pumping Concrete:

(1) Slab screeds and bulkheads shall be set to specified alignment and elevations permitting a maximum tolerance of 1/4 inch plus or minus. For suspended slab forms provide camber in the forms profile to prevent downward deflection when filled with concrete.

(2) Before pumping is started, prime the delivery pipe or hose by pumping mortar through the line using 5 gallons of mortar for each 50 feet of delivery pipe. Do not deposit mortar in the forms.

27.11 SURFACE FINISHES

Add the following items to the end of Section 303.03.S, "Surface Finishes":

A. Form Tie Holes Patching: The surface form tie holes in the wall surfaces shall be roughened or abrasion blasted and cleaned, the tie holes shall then be coated with a water insensitive epoxy or an acceptable bonding agent and properly filled by damp-packing with a mortar of drypack consistency. The mortar shall have a mix of one part of cement to one-part sand ratio. The amount of added water to the cement-sand mix shall be such that the mortar can be driven into the voids and will compact properly. The outside tie holes shall not be drypacked any sooner than 7 days after the inside holes have been drypacked.

B. Reservoir Concrete Finishes Schedule

(1) Reservoir floor: Wood-float surface conforming to specified slope.

(2) Reservoir wall, columns and outside edge of roof slab and wall footing: See WSS Section 303.06.C.6.

(3) Reservoir roof slab: The top surface shall receive a steel trowel finish which is subsequently swept with a steel or hard-bristled broom to leave a fine uniformly scratched concrete surface.

C. Wood-Float Finish

(1) This finish requires an integral finish by wood-float after screeding, to compact the surface evenly.

(2) Any excess surface water shall be removed before floating and no mortar shall be used for leveling.

D. Steel Trowel Finish

(1) This shall be an integral finish obtained by trowelling with a steel trowel after the surface has been floated and allowed to stand until all water-sheen has disappeared.

(2) Finish shall be an integral finish obtained by trowelling with a steel trowel after the surface has been floated and allowed to stand until all water-sheen has disappeared.

(3) Cement or mixture of cement and sand, shall not be spread on surfaces to absorb excess water or to stiffen the concrete.

(4) Trowelling shall produce a dense, smooth, impervious surface free from defects and blemishes.

27.12 CURING COMPOUNDS

Curing compound is not allowed for reservoir concrete with the approval of the Board of Water Supply.

27.13 PROTECTING AND CURING

Replace Section 303.03R "Protecting and Curing" with the following:

A. All fresh concrete shall be adequately protected from injurious action by the sun, heavy rains and mechanical injury and shall not be allowed to dry out from the time it is placed until the expiration of the minimum curing period specified here.

B. For the reservoir, all horizontal, screeded and floated surfaces, exposed to drying winds and sunlight, shall be wet cured by one or more of the methods described in WSS Section 303.03.R for as long as possible, but for at least 10 days, to minimize the loss of moisture from the concrete top surface. Note, the exposed edge of roof slab shall also be protected from drying by the curing method used for the roof slab.

C. For wall surfaces exposed during the curing period shall be covered with burlap cloth weighted at bottom to prevent displacement by wind, shall be kept wet with soak hose or other approved method for the full curing period. Alternatively, the wall forms can be left in-place for the full curing period.

D. Prior to placing the reservoir in service or the surface is coated, the surfaces coated with curing compound shall be pressure blasted with water or abrasive to completely remove the compound.

E. The Department of Water reserves the right to reject concrete that was not provided with the specified curing.

F. Delete the second sentence from the first paragraph in Section 303.12.A "Protection of Reservoir - General".

27.14 CONCRETE REPAIR

A. Defective surfaces, such as honeycomb, shall be cut out entirely until homogeneous concrete is met, even if it means going through the entire wall, floor or roof slab.

B. Such areas shall be coated with a two-component, 100% solids, moisture-tolerant, high-modulus structural epoxy paste bonding material, such as Sikadur 31, Hi-Mod Gel by Sika, or approved equal, which shall be applied in accordance with the manufacturer's instructions, before damp-packing the area with a mix consisting of one part of Portland cement and two parts of sand and fine gravel, epoxy and sand mix, or any combination of materials and mixes as the situation dictates in the opinion of the Department of Water.

C. The water content of the repair mortar material shall be such that a ball of the mix may be squeezed in the hand without bringing free water to the surface.

D. Repair mortar material shall be tamped into place and finished to match adjacent concrete surfaces.

E. When a patch is to be placed in multiple lifts, an approved epoxy bonding agent shall be applied between lifts in accordance with the manufacturer's recommendations

F. Surfaces which have been damp-packed shall be kept continuously damp to cure for a period of not less than seven days after completing the damp-pack operation, by the curing procedure described below.

G. Neither Embeco, calcium chloride or fast-setting cements/additives shall be used for filling honeycomb areas, nor shall they be mixed with damppack material. Contractor shall provide certification that any material placed on or

in the concrete wall shall be free of chlorides and other materials corrosive to reinforcing steel.

27.15 EPOXY ADHESIVE INJECTION OF CONCRETE CRACKS

A. Repair Criteria: All cracks with a width of 0.02 inches or larger shall be repaired using this procedure.

B. Epoxy injection shall be performed by a manufacturer trained and certified applicator.

C. Contractor's/Subcontractor's operator engaged in the epoxy injection process shall have satisfactory operator experience in the methods of restoring concrete structures utilizing the specific epoxy injection process indicated. Operator's experience shall include previous repairs of cracked or damaged concrete structures, the technical knowledge of correct material selection and use, and the operation, maintenance and troubleshooting of equipment.

D. Epoxy Resin Adhesive for Injection: Epoxy adhesive shall be 100% solids, 2-part water insensitive, low-viscosity epoxy resin. Epoxy shall be suitable for repairing both dry and damp cracks. Epoxy shall develop a minimum tensile strength (ASTM D638) of 8,500 psi at 7 days, and a minimum compressive strength (ASTM D695) of 12,000 psi at 28 days. Products meeting these requirements include 'SIKADUR 35 HI-MOD LV', by Sika, Lyndhurst, NJ; or approved equal.

E. The crack surface seal material shall have adequate strength to hold injection fittings (injection ports) firmly in place and to resist injection pressures adequately to prevent leakage during injection. The material shall be compatible and from the same manufacturer as the epoxy resin adhesive product.

F. Pressure Injection Equipment:

(1) The equipment used to meter and mix the two injection adhesive components and inject the mixed adhesive into the crack shall be portable, positive-displacement type pumps with interlock to provide positive ratio control of exact proportions of the two components at the nozzle. The pumps shall be electric or air powered and shall provide in-line metering and mixing.

(2) The injection equipment shall have automatic pressure control capable of discharging the mixed adhesive at any pre-set pressure up to 200 psi plus or minus 5 psi and shall be equipped with a manual pressure control override.

(3) The injection equipment shall have the capability of maintaining the volume ratio for the injection adhesive prescribed by the manufacturer of the adhesive within a tolerance of plus or minus 5 percent by volume at any discharge pressure up to 200 psi.

G. Injection Equipment Pressure Test:

(1) The mixing head of the injection equipment shall be connected and the equipment run until clear uniformly mixed material flows into the purge pail. The Operator shall engage the equipment shut-off nozzle valve and subsequently bump the on-off switch until the pressure reaches 200 psi. If pressure is maintained between 190-200 psi for one minute, check valves shall be considered to be functioning properly and the injection may proceed. If pressure drops below 190 psi, Contractor shall be required to have new seals installed on the check valves and the equipment shall be subsequently retested.

(2) The pressure test shall be run for each injection unit at the beginning and after meal breaks of every shift that the unit is used.

(3) The adequacy and accuracy of the equipment shall be solely the responsibility of the Contractor.

H. Mix Ratio Test:

(1) The epoxy mixture ratio shall be monitored continuously while injecting by placing a strip of masking tape on the sides of the A & B reservoirs full height. After filling reservoirs, the A & B levels shall be marked and monitored while running injection machine into purge pail for a period of one minute. The difference in liquid height shall then be compared to verify the correct volume ration is being dispensed.

(2) If the dispensing ratio is incorrect, the equipment shall be adjusted and retested.

(3) The ratio test shall be run for each injection unit at the beginning and after meal breaks of every shift that the unit is used.

I. Proof of Mix Ratio Test:

(1) At all times during the course of the work the Contractor shall keep complete and accurate records available to the Department of Water of the equipment pressure and mix ratio tests specified above.

(2) In addition, the Department of Water at any time without prior

notification of the Contractor, may request the Contractor to conduct the tests specified above in the presence of the Department of Water.

J. Injection Repair Preparation:

(1) The substrate surface at the seal material application shall be clean, no dirt, dust, grease, oil, efflorescence or other foreign matter that may be detrimental to the integrity of the epoxy bond. Acids and corrosives shall not be permitted to be used.

(2) Entry ports shall be placed along the crack spaced not more than the thickness of the concrete section to be repaired.

(3) Surface seal material shall be applied to the face of the crack between the entry ports. For through cracks, surface seal shall be applied to both faces, where possible.

(4) Surface seal material shall be allowed to cure to gain adequate strength before proceeding with pressure injection.

K. Epoxy Adhesive Injection:

(1) Begin injection at lower entry port for vertical applications and at one end of the crack in horizontal applications, continuing until epoxy adhesive appears at the next entry port in line.

(2) Epoxy injection shall progress along the crack to the next adjacent port where epoxy adhesive has appeared.

(3) Epoxy adhesive injection shall be performed sequentially along the ports until cracks are completely filled.

(4) If port-to-port travel of epoxy adhesive is not achieved, the work shall immediately be stopped and the Department of Water notified.

L. Finishing:

(1) After cracks are completely filled, epoxy adhesive shall be cured to prevent any draining or runback of epoxy material from cracks.

(2) Any surface seal material, injection ports and injection adhesive shall be removed from concrete surfaces.

(3) The face of the crack shall be finished flush to the adjacent concrete surface showing no indentations or protrusions caused by the placement of entry ports.

27.16 PAYMENT

Payment for RESERVOIR CONCRETE WORK will not be made directly but shall be included in the payment of which it is a part. Such payment shall represent full compensation for furnishing all materials, labor, tools, equipment and incidentals required to complete the work.