SECTION 03 30 53
(SHORT-FORM) CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies cast-in-place structural concrete and material and mixes for other concrete.

1.2 RELATED WORK

A. Materials testing and inspection during construction: Section 01 45 29, TESTING LABORATORY SERVICES.
B. Concrete roads, walks, and similar exterior site work: Section 32 05 23, CEMENT AND CONCRETE FOR EXTERIOR IMPROVEMENTS.

1.3 TOLERANCES

A. Formwork: ACI 117, except the elevation tolerance of formed surfaces before removal of shores is +0 inch and -3/4 inch.
B. Reinforcement Fabricating and Placing: ACI 117, except that fabrication tolerance for bar sizes Nos. 10, 13, and 16 (Nos. 3, 4, and 5) (Tolerance Symbol 1 in Fig. 2.1(a), ACI, 117) used as column ties or stirrups is +0 inch and--1/2 inch where gross bar length is less than 12 feet, or +0 inch and -3/4 inch where gross bar length is 12 feet or more.
C. Cross-Sectional Dimension: ACI 117, except tolerance for thickness of slabs 12 inches or less is +3/4 inch and -1/4 inch. Tolerance of thickness of beams more than 12 inches but less than 3 feet is +3/4 inch and -3/8 inch.
D. Slab Finishes: ACI 117, Section 4.5.6, F-number method in accordance with ASTM E1155, with a conventional straight edged finish.

1.4 REGULATORY REQUIREMENTS

A. ACI SP-66 - ACI Detailing Manual.
B. ACI 318 - Building Code Requirements for Reinforced Concrete.
C. ACI 301 – Standard Specifications for Structural Concrete.

1.5 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
B. Concrete Mix Design.
C. Shop Drawings:

1. Submit Steel Reinforcement Shop Drawings and Product Data to include all information necessary for fabrication and placement of reinforcement.
2. Indicate grades of reinforcing steel.
3. Clearly indicate the splice length for every size and type of bar used.
4. Indicate the type, size and location of all accessories required for the proper assembly, placement and support of the reinforcement.
5. Provide layout drawings of all floor slabs and formed concrete indicating construction, control, and expansion joint locations.

D. Manufacturer's Certificates: Air-entraining admixture, chemical admixtures, curing compounds.

1.6 APPLICABLE PUBLICATIONS

A. Publications listed below form a part of this specification to extent referenced. Publications are referenced in text by the basic designation only. Comply with the latest edition of referenced publications unless otherwise specified

B. American Concrete Institute (ACI):

117	Specification for Tolerances for Concrete Construction and Materials and Commentary
211.1	Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
211.2	Standard Practice for Selecting Proportions for Structural Lightweight Concrete
214	Recommended Practice for Evaluation of Strength Test Results of Concrete
301	Standard Specifications for Structural Concrete
304R	Guide for Measuring, Mixing, Transporting, and Placing Concrete
305.1	Specification for Hot Weather Concreting
306.1	Standard Specification for Cold Weather Concreting
308R	Standard Practice for Curing Concrete
309R	Guide for Consolidation of Concrete
SP-66	ACI Detailing Manual
318	Building Code Requirements for Structural Concrete and Commentary
347R	Guide to Formwork for Concrete

C. American National Standards Institute and American Hardboard Association (ANSI/AHA):

A135.4	Basic Hardboard

D. ASTM International (ASTM):

A82	Standard Specification for Steel Wire, Plain, for Concrete Reinforcement
A185	Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
A615/A615M	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
A653	Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvanized) by the Hot-Dip Process
A706	Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
A996/A996M	Standard Specification for Rail Steel and Axle Steel Deformed Bars for Concrete Reinforcement
A1064/A1064M	Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
C31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
C33/C33M	Standard Specification for Concrete Aggregates
C39/C39M	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
C94/C94M	Standard Specification for Ready Mixed Concrete
C143/C143M	Standard Test Method for Slump of Hydraulic Cement Concrete
C150/C150M	Standard Specification for Portland Cement
C171	Standard Specification for Sheet Materials for Curing Concrete
C172	Standard Specification for Sampling Freshly Mixed Concrete
C173	Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method

C192/C192M	Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
C231	Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
C260/C260M	Standard Specification for Air-Entraining Admixtures for Concrete
C309	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
C330/C330M	Standard Specification for Lightweight Aggregates for Structural Concrete
C494/C494M	Standard Specification for Chemical Admixtures for Concrete
C496	Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens
C567	Standard Test Method for Density of Structural Lightweight Concrete
C618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
C666	Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing
C881	Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
C1107	Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink)
D6	Standard Test Method for Loss on Heating of Oil and Asphaltic Compounds
D297	Standard Test Methods for Rubber Products-Chemical Analysis
D1751	Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types)
D4397	Standard Specification for Polyethylene Sheeting for Construction, Industrial and Agricultural Applications

E1155	Standard Test Method for Determining F_F Floor Flatness and F_L Floor Levelness Numbers
E1745	Standard Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs

E. American Welding Society (AWS):

D1.4	Structural Welding Code Reinforcing Steel

F. Concrete Reinforcing Steel Institute (CRSI):

DA4	Manual of Standard Practice

G. Federal Specifications (Fed. Spec.):

MM-L-751H	Lumber Softwood

H. U.S. Department of Commerce Product Standard (PS):

PS 1	Construction and Industrial Plywood

I. U.S. Army Corps of Engineers Handbook for Concrete and Cement:

CRD C513	Rubber Waterstops
CRD C572	Polyvinyl Chloride Waterstops

PART 2 - PRODUCTS

2.1 FORMS

A. Wood: Fed Spec MM-L-751H, free from loose knots and suitable to facilitate finishing concrete surface specified; tongue and grooved.

B. Plywood: PS-1 Exterior Grade B (concrete form) 5/8 inch, or 3/4 inch thick for unlined contact form. B-B High Density Concrete Form Overlay optional.

C. Metal for Concrete Rib Type Construction: Steel (removal type) of suitable weight and form to provide required rigidity.

D. Permanent Steel Form for Concrete Slabs: Corrugated, ASTM A653, Grade E, and Galvanized, ASTM A653, G90. Provide venting where insulating concrete fill is used.

E. Form Lining:

1. Hardboard: ANSI/AHA A135.4, Type 2, Grade 2-M-2, exterior bond not less than 3/16 inch thick.

2. Plywood: Grade B-B Exterior (concrete-form) not less than 1/4 inch thick.

3. Plastic, fiberglass, or elastomeric capable of reproducing the desired pattern or texture.

F. Form Ties: Develop a minimum working strength of 3000 pounds when fully assembled. Ties shall be adjustable in length to permit tightening of forms and not have any lugs, cones, washers to act as spreader within form, nor leave a hole larger than 3/4 inch diameter, or a depression in exposed concrete surface, or leave metal closer than 1 1/2 inches to concrete surface. Wire ties not permitted. Cutting ties back from concrete face not permitted.

G. Form releasing agents to be commercial formulations that will not bond with, stain or adversely affect concrete surfaces. Agents must not impair subsequent treatment of concrete surfaces depending upon bond or adhesion nor impede the wetting of surfaces to be cured with water or curing compounds. If special form liners are to be used, follow the recommendation of the form coating manufacturer. Submit manufacturer's recommendation on method and rate of application of form releasing agents.

2.2 MATERIALS

A. Portland Cement: ASTM C150, Type I or II.

B. Fly Ash: ASTM C618, Class C or F including supplementary optional requirements relating to reactive aggregates and alkalis, and loss on ignition (LOI) not to exceed 5 percent.

C. Coarse Aggregate: ASTM C33, Size 67. Size 467 may be used for footings and walls over 12 inches thick. Provide Size 7 coarse aggregate for applied topping, encasement of steel columns and metal pan stair fill. Maximum size of coarse aggregates not more than one-fifth of narrowest dimension between sides of forms, one-third of depth of slabs, nor three-fourth of minimum clear spacing between reinforcing bars.

D. Fine Aggregate: ASTM C33. Fine aggregate for applied concrete floor topping shall pass a No. 4 sieve, 10 percent maximum shall pass a No. 100 sieve.

E. Lightweight Aggregate for Structural Concrete: ASTM C330, Table 1

F. Mixing Water: Fresh, clean, and potable.

G. Air-Entraining Admixture: ASTM C260.

H. Chemical Admixtures: ASTM C494.

1. Water Reducing Admixture: ASTM C494, Type A and not contain more chloride ions than are present in municipal drinking water.

2. Water Reducing, Retarding Admixture: ASTM C494, Type D and not contain more chloride ions than are present in municipal drinking water.

3. High-Range Water-Reducing Admixture (Superplasticizer): ASTM C494, Type F or G, and not contain more chloride ions than are present in municipal drinking water.

4. Non-Corrosive, Non-Chloride Accelerator: ASTM C494, Type C or E, and not contain more chloride ions than are present in municipal drinking water. Admixture manufacturer must have long-term non-corrosive test data from an independent testing laboratory of at least one year duration using an acceptable accelerated corrosion test method such as that using electrical potential measures.

5. Calcium Nitrite corrosion inhibitor: ASTM C494 Type C.

6. Prohibited Admixtures: Calcium chloride, thiocyanate or admixtures containing more than 0.05 percent chloride ions are not permitted.

7. Certification: Written conformance to the requirements above and the chloride ion content of the admixture prior to mix design review.

I. Vapor Barrier: ASTM E1745, 15 mil thickness.

J. Reinforcing Steel: ASTM A615 or ASTM A996, deformed. See structural drawings for grade.

K. Welded Wire Fabric: ASTM A1064.

L. Reinforcing Bars to be Welded: ASTM A706.

M. Galvanized Reinforcing Bars: ASTM A767.

N. Reinforcement for Metal Pan Stair Fill: 2 inch wire mesh, either hexagonal mesh at 1.5 pounds per square yard, or square mesh at 1.17 pounds per square yard.

O. Supports, Spacers, and Chairs: Types which will hold reinforcement in position shown in accordance with requirements of ACI 318 except as specified.

P. Expansion Joint Filler: ASTM D1751.

Q. Sheet Materials for Curing Concrete: ASTM C171.

R. Abrasive Aggregates: Aluminum oxide grains or emery grits.

S. Liquid Densifier/Sealer: 100 percent active colorless aqueous siliconate solution.

T. Liquid Membrane-forming Compounds for Curing Concrete: ASTM C309, Type I, with fugitive dye. Compound shall be compatible with scheduled surface treatment, such as paint and resilient tile, and shall not discolor concrete surface.

U. Grout, Non-Shrinking: ASTM C1107, premixed ferrous or non-ferrous, mixed and applied in accordance with manufacturer's recommendations. Grout cannot show settlement or vertical drying shrinkage at 3 days or thereafter based on initial measurement made at time of placement. Grout must produce a compressive strength of minimum 2500 psi at 3 days and minimum 5000 psi at 28 days. Furnish test data from an independent laboratory indicating that the grout when placed at a fluid consistency shall achieve 95 percent bearing under a 4 foot by 4 foot base plate. Where high fluidity or increased

placing time is required, furnish test data from an independent laboratory indicating that the grout when placed at a fluid consistency shall achieve 95 percent under an 18 inch by 36 inch base plate.

V. Adhesive Binder: ASTM C881:

1. Bentonite Water Stop: Flexible strip of bentonite 1 inch by 3/4 inch, weighing 5.85 lbs. per foot composed of Butyl Rubber Hydrocarbon (ASTM D297), Bentonite (SS-S-210-A) and Volatile Matter (ASTM D6).

2. Porous Backfill: Crushed stone or gravel graded from 1 inch to 3/4 inch.

3. Synthetic Fibers: Monofilament or fibrillated polypropylene fibers for secondary reinforcing of concrete members. Use appropriate length and 1.5 lb. per cubic yard. Product shall have a UL rating.

4. Steel Fibers: ASTM A820, Type I cold drawn, high tensile steel wire for use as primary reinforcing in slab-on-grade. Minimum dosage rate 18 kg/m3 (30 lb. per cubic yard).

5. Epoxy Joint Filler: Two component, 100 percent solids compound, with a minimum shore D hardness of 50.

6. Bonding Admixture: Non-rewettable, polymer modified, bonding compound.

7. Architectural Concrete: For areas designated as architectural concrete on the Contract Documents, use colored cements and specially selected aggregates as necessary to produce a concrete of a color and finish which exactly matches the designated sample panel.

2.3 CONCRETE MIXES

A. Design of concrete mixes using materials specified as set forth under Option C of ASTM C94.

B. Compressive strength at 28 days:
   1. Foundations: Minimum 4000 psi
   2. Slabs: Minimum 3500 psi
   3. All Other: Minimum 3000 psi

C. Establish strength of concrete by testing prior to beginning concreting operation. Test consists of average of three cylinders made and cured in accordance with ASTM C192 and tested in accordance with ASTM C39.

D. Cement and water factor (See Table I): Maintain minimum cement factors in Table I regardless of compressive strength developed above minimums. Fly ash may be substituted for up to 20 percent of the minimum cement factor at option of Contractor, except fly ash may not be used in concrete designated as architectural concrete.

TABLE I - CEMENT AND WATER FACTORS FOR CONCRETE

Concrete: Strength	Non-Air-Entrained		Air-Entrained	
Min. 28 Day Comp. Str. MPa (psi)	Min. Cement kg/m^3 (lbs/c. yd)	Max. Water Cement Ratio	Min. Cement kg/m^3 (lbs/c. yd)	Max. Water Cement Ratio
35 (5000)[1,3]	375 (630)	0.45	385 (650)	0.40
30 (4000)[1,3]	325 (550)	0.55	340 (570)	0.50
25 (3000)[1,3]	280 (470)	0.65	290 (490)	0.55
25 (3000)[1,2]	300 (500)	*	310 (520)	*

1. If trial mixes are used, the proposed mix design must achieve a compressive strength 1200 psi in excess of f'c. For concrete strengths above 5000 psi, the proposed mix design must achieve a compressive strength 1400 psi in excess of f'c.
2. Lightweight Structural Concrete. Pump mixes may require higher cement values.
3. For concrete exposed to high sulfate content soils maximum water cement ratio is 0.44.

* Determined by Laboratory in accordance with ACI 211.1 for normal concrete or ACI 211.2 for lightweight structural concrete.

E. Maximum Slump: Maximum slump, as determined by ASTM C143 with tolerances as established by ASTM C94, for concrete to be vibrated shall be as shown in Table II.

TABLE II - MAXIMUM SLUMP, INCHES*

Type of Construction	Normal Weight Concrete	Lightweight Structural Concrete
Reinforced Footings and Substructure Walls	3 inches	3 inches
Slabs, Beams, Reinforced Walls, and Building Columns	4 inches	4 inches

* Slump may be increased by the use of the approved high-range water-reducing admixture (superplasticizer). Tolerances as established by ASTM C94. Concrete containing the high-range-water-reducing admixture may have a maximum slump of 9 inches. The concrete shall arrive at the job site at a slump of 2 inches to 3 inches, and 3

inches to 4 inches for lightweight concrete. This should be verified, and then the high-range-water-reducing admixture added to increase the slump to the approved level.

F. Air-entrainment is required for all exterior concrete and as required for Section 32 05 23. Air content shall conform to ACI 318 Table 4.4.1.

G. High early strength concrete, made with Type III cement or Type I cement plus non-corrosive accelerator, shall have a 7-day compressive strength equal to specified minimum 28 day compressive strength for concrete type specified made with standard Portland cement.

H. Concrete slabs placed at air temperatures below 50 degrees Fahrenheit use non-corrosive, non-chloride accelerator. Concrete required to be air entrained use approved air entraining admixture. Pumped concrete, synthetic fiber concrete, architectural concrete, concrete required to be watertight, and concrete with a water/cement ratio below 0.50 use high-range water-reducing admixture (superplasticizer).

I. Durability: Use air entrainment for exterior exposed concrete subjected to freezing and thawing and other concrete shown or specified. Air content as shown in ACI 318 Table 4.4.1.

J. Enforcing Strength Requirements: Test as specified in Section 01 45 29, TESTING LABORATORY SERVICES, during the progress of the work. Seven day tests may be used as indicators of 28 day strength. Average of any three 28 day consecutive strength tests of laboratory cured specimens representing each type of concrete shall be equal to or greater than specified strength. No single test shall be more than 500 psi below specified strength. Interpret field test results in accordance with ACI 214. Should strengths shown by test specimens fall below required values, Resident Engineer may require any one or any combination of the following corrective actions, at no additional cost to the Government:

1. Require changes in mix proportions by selecting one of the other appropriate trial mixes or changing proportions, including cement content, of approved trial mix.

2. Require additional curing and protection.

3. If five consecutive tests fall below 95 percent of minimum values given in Table I or if test results are so low as to raise a question as to the safety of the structure, Resident Engineer may direct Contractor to take cores from portions of the structure. Use results from cores tested by the Contractor retained testing agency to analyze structure.

4. If strength of core drilled specimens falls below 85 percent of minimum value given in Table I, Resident Engineer may order load tests, made by Contractor retained testing

agency, on portions of building so affected. Load tests in accordance with ACI 318 and criteria of acceptability of concrete under test as given therein.

5. Concrete work, judged inadequate by structural analysis, by results of load test, or for any reason, shall be reinforced with additional construction or replaced, if directed by the Resident Engineer.

2.4 BATCHING AND MIXING

A. Store, batch, and mix materials as specified in ASTM C94.

1. Job-Mixed: Mix in a batch mixer in manner specified for stationary mixers in ASTM C94.

2. Ready-Mixed: Comply with ASTM C94, except use of non-agitating equipment for transporting concrete to the site will not be permitted. With each load of concrete delivered to project, ready-mixed concrete producer must furnish, in duplicate, certification as required by ASTM C94. Maximum delivery temperature of concrete is 100 degrees Fahrenheit. Minimum delivery temperature as follows:

Atmospheric Temperature	Minimum Concrete Temperature
30.1 degrees to 40 degrees F	60 degrees F.
0 degrees to 30 degrees F.	70 degrees F.

3. Services of aggregate manufacturer's representative shall be furnished during the design of trial mixes and as requested by the Resident Engineer for consultation during batching, mixing, and placing operations of lightweight structural concrete. Services will be required until field controls indicate that concrete of required quality is being furnished. Representative shall be thoroughly familiar with the structural lightweight aggregate, adjustment and control of mixes to produce concrete of required quality. Representative shall assist and advise Resident Engineer.

4. Mixing structural lightweight concrete: Charge mixer with 2/3 of total mixing water and all of the aggregate. Mix ingredients for not less than 30 seconds in a stationary mixer or not less than 10 revolutions at mixing speed in a truck mixer. Add remaining mixing water and other ingredients and continue mixing. Above procedure may be modified as recommended by aggregate producer.

PART 3 - EXECUTION

3.1 FORMWORK

A. Installation shall conform to ACI 347. Formwork shall be sufficiently tight to hold concrete without leakage, sufficiently braced to withstand vibration of concrete, and to carry, without appreciable deflection while remaining within allowable construction tolerances, all dead and live loads to which they may be subjected. The Contractor shall retain a registered Professional Engineer to design the formwork, shores, and reshores.

1. Form boards and plywood forms may be reused for contact surfaces of exposed concrete only if thoroughly cleaned, patched, and repaired and Resident Engineer approves their reuse.

2. Provide forms for concrete footings unless Resident Engineer determines forms are not necessary.

3. Corrugated fiberboard forms: Place forms on a smooth firm bed, set tight, with no buckled cartons to prevent horizontal displacement, and in a dry condition when concrete is placed.

B. Treating and Wetting: Treat or wet contact forms as follows:
   1. Coat plywood and board forms with non-staining form sealer. In hot weather cool forms by wetting with cool water just before concrete is placed.
   2. Clean and coat removable metal forms with light form oil before reinforcement is placed. In hot weather, cool metal forms by thoroughly wetting with water just before placing concrete.
   3. Use sealer on reused plywood forms as specified for new material.

C. Size and Spacing of Studs: Size and space studs, wales and other framing members for wall forms so as not to exceed safe working stress of kind of lumber used nor to develop deflection greater than 1/270 of free span of member.

D. Unlined Forms: Use plywood forms to obtain a smooth finish for concrete surfaces. Tightly butt edges of sheets to prevent leakage. Back up all vertical joints solidly and nail edges of adjacent sheets to same stud with 6d box nails spaced not over 6 inches apart.

E. Lined Forms: May be used in lieu of unlined plywood forms. Back up form lining solidly with square edge board lumber securely nailed to studs with all edges in close contact to prevent bulging of lining. No joints in lining and backing may coincide. Nail abutted edges of sheets to same backing board. Nail lining at not over 8 inches on center along

edges and with at least one nail to each square foot of surface area; nails to be 3d blued shingle or similar nails with thin flatheads.

F. Architectural Liner: Attach liner as recommended by the manufacturer with tight joints to prevent leakage.

G. Wall Form Ties: Locate wall form ties in symmetrically level horizontal rows at each line of wales and in plumb vertical tiers. Space ties to maintain true, plumb surfaces. Provide one row of ties within 6 inches above each construction joint. Space through ties adjacent to horizontal and vertical construction joints not over 18 inches on center.

1. Tighten row of ties at bottom of form just before placing concrete and, if necessary, during placing of concrete to prevent seepage of concrete and to obtain a clean line. Ties to be entirely removed shall be loosened 24 hours after concrete is placed and shall be pulled from least important face when removed.

2. Coat surfaces of all metal that is to be removed with paraffin, cup grease or a suitable compound to facilitate removal.

H. Inserts, sleeves, and similar items: Flashing reglets, steel strips, masonry ties, anchors, wood blocks, nailing strips, grounds, inserts, wire hangers, sleeves, drains, guard angles, forms for floor hinge boxes, inserts or bond blocks for elevator guide rails and supports, and other items specified as furnished under this and other sections of specifications and required to be in their final position at time concrete is placed shall be properly located, accurately positioned, and built into construction, and maintained securely in place.

1. Locate inserts or hanger wires for furred and suspended ceilings only in bottom of concrete joists, or similar concrete member of overhead concrete joist construction.

2. Install sleeves, inserts and similar items for mechanical services in accordance with drawings prepared specially for mechanical services. Contractor is responsible for accuracy and completeness of drawings and shall coordinate requirements for mechanical services and equipment.

3. Do not install sleeves in beams, joists or columns except where shown or permitted by Resident Engineer. Install sleeves in beams, joists, or columns that are not shown, but are permitted by the Resident Engineer, and require no structural changes, at no additional cost to the Government.

4. Minimum clear distance of embedded items such as conduit and pipe is at least three times diameter of conduit or pipe, except at stub ups and other similar locations.

5. Provide recesses and blockouts in floor slabs for door closers and other hardware as necessary in accordance with manufacturer's instructions.

I. Construction Tolerances:

1. Set and maintain concrete formwork to assure erection of completed work within tolerances specified to accommodate installation or other rough and finish materials.
2. Cast-in-place concrete installed as part of, or in the complexes surrounding, columbarian or memorial wall elements shall have concrete (on or above finished grade) constructed to dimensions indicated on the Drawings within 1/4 inch of location and elevation.
3. Engage a professional surveyor to survey the formwork for the exposed portions of the foundations for the columbarium or memorial walls, including wall segments, piers and/or columns, prior to concrete being poured. If the forms are not correct, they must be corrected and resurveyed. When correct, provide a written certification from the surveyor, to the COTR, that the forms are set according to the Drawings, within the allowable tolerances for elevation, location, orientation, and dimensions called for on the Drawings.
4. Properly brace the forms so the set concrete is correct within the allowable construction tolerances when the forms are removed.
5. Upon removal of the forms, the professional surveyor must survey the placed concrete and provide information to the COTR where the work is not in conformance with the Drawings, within the allowable construction tolerances. The work cannot progress until the exposed concrete for the foundations are brought into compliance.
6. Remedial work necessary for correcting installations that is in excess of allowable tolerances are the responsibility of the Contractor.
7. Erected work that exceeds specified tolerance limits shall be remedied or removed and replaced, at no additional cost to the NCA.
8. Any remediation work is subject to approval of the COTR in advance of the work.
9. Permissible surface irregularities for various classes of materials are defined as "finishes" in specification sections covering individual materials. They are to be distinguished from tolerances specified which are applicable to surface irregularities of structural elements.

3.2 REINFORCEMENT

A. Details of concrete reinforcement, unless otherwise shown, shall be in accordance with ACI 318 and ACI SP-66, unless otherwise shown.

B. Placing: Place reinforcement conforming to CRSI DA4, unless otherwise shown.

1. Place reinforcing bars accurately and tie securely at intersections and splices with 16 gauge black annealed wire. Secure reinforcing bars against displacement during the placing of concrete by spacers, chairs, or other similar supports. Portions of supports, spacers, and chairs in contact with formwork shall be made of plastic in areas that will be exposed when building is occupied. Type, number, and spacing of supports conform to ACI SP-66. Where concrete slabs are placed on ground, use concrete blocks or other non-corrodible material of proper height, for support of reinforcement. Use of brick or stone supports will not be permitted.

2. Lap welded wire fabric at least 1 1/2 mesh panels plus end extension of wires not less than 12 inches in structural slabs. Lap welded wire fabric at least 1/2 mesh panels plus end extension of wires not less than 6 inches in slabs on grade.

3. Splice column steel at no points other than at footings and floor levels unless otherwise shown.

C. Spacing: Minimum clear distances between parallel bars, except in columns and multiple layers of bars in beams shall be equal to nominal diameter of bars. Minimum clear spacing is 1 inch or 1 1/3 times maximum size of coarse aggregate.

D. Splicing: Splices of reinforcement made only as required or shown or specified. Accomplish splicing as follows:

1. Lap splices: Do not use lap splices for bars larger than Number 36 (Number 11). Minimum lengths of lap as shown.

2. Welded splices: Splicing by butt welding of reinforcement permitted providing the weld develops in tension at least 125 percent of the yield strength (fy) for the bars. Welding conform to the requirements of AWS D1.4. Welded reinforcing steel conform to the chemical analysis requirements of AWS D1.4.

a. Submit test reports indicating the chemical analysis to establish weldability of reinforcing steel.

b. Submit a field quality control procedure to insure proper inspection, materials and welding procedure for welded splices.

c. Department of Veterans Affairs retained testing agency shall test a minimum of three splices, for compliance, locations selected by Resident Engineer.

3. Mechanical Splices: Develop in tension and compression at least 125 percent of the yield strength (fy) of the bars. Stresses of transition splices between two reinforcing bar sizes based on area of smaller bar. Provide mechanical splices at locations indicated.

Use approved exothermic, tapered threaded coupling, or swaged and threaded sleeve. Exposed threads and swaging in the field not permitted.

a. Initial qualification: In the presence of Resident Engineer, make three test mechanical splices of each bar size proposed to be spliced. Department of Veterans Affairs retained testing laboratory will perform load test.

b. During installation: Furnish, at no additional cost to the Government, one companion (sister) splice for every 50 splices for load testing. Department of Veterans Affairs retained testing laboratory will perform the load test.

E. Bending: Bend bars cold, unless otherwise approved. Do not field bend bars partially embedded in concrete, except when approved by Resident Engineer.

F. Cleaning: Metal reinforcement, at time concrete is placed, shall be free from loose flaky rust, mud, oil, or similar coatings that will reduce bond.

G. Future Bonding: Protect exposed reinforcement bars intended for bonding with future work by wrapping with felt and coating felt with a bituminous compound unless otherwise shown.

3.3 VAPOR BARRIER

A. Except where membrane waterproofing is required, place interior concrete slabs on a continuous vapor barrier.

B. Place 4 inches of fine granular fill over the vapor barrier to act as a blotter for concrete slab.

C. Lap joints 6 inches and seal with a compatible waterproof pressure-sensitive tape.

D. Patch punctures and tears.

3.4 CONSTRUCTION JOINTS

A. Unless otherwise shown, location of construction joints to limit individual placement shall not exceed 80 feet in any horizontal direction, except slabs on grade which shall have construction joints shown. Allow 48 hours to elapse between pouring adjacent sections unless this requirement is waived by Resident Engineer.

B. Locate construction joints in suspended floors near the quarter-point of spans for slabs, beams or girders, unless a beam intersects a girder at center, in which case joint in girder shall be offset a distance equal to twice width of beam. Provide keys and inclined dowels as shown. Provide longitudinal keys as shown.

C. Place concrete for columns slowly and in one operation between joints. Install joints in concrete columns at underside of deepest beam or girder framing into column.

D. Allow 2 hours to elapse after column is cast before concrete of supported beam, girder or slab is placed. Place girders, beams, grade beams, column capitals, brackets, and haunches at the same time as slab unless otherwise shown.

3.5 CONTROL JOINTS

A. Control joints to be a maximum 1-1/2 inch deep sawn or tooled joints within concrete paving as depicted on Drawings. Control joints are not to break or disrupt concrete paving reinforcement.

B. Control joints to be used to define individual concrete paving areas with nominal 2:1 ratio of length to width maximum.

3.6 EXPANSION JOINTS

A. Clean expansion joint surfaces before installing premolded filler and placing adjacent concrete.

3.7 PLACING CONCRETE

A. Preparation:
   1. Remove hardened concrete, wood chips, shavings and other debris from forms.
   2. Remove hardened concrete and foreign materials from interior surfaces of mixing and conveying equipment.
   3. Have forms and reinforcement inspected and approved by Resident Engineer before depositing concrete.
   4. Provide runways for wheeling equipment to convey concrete to point of deposit. Keep equipment on runways which are not supported by or bear on reinforcement. Provide similar runways for protection of vapor barrier on coarse fill.

B. Bonding: Before depositing new concrete on or against concrete which has been set, thoroughly roughen and clean existing surfaces of laitance, foreign matter, and loose particles.
   1. Preparing surface for applied topping:
      a. Remove laitance, mortar, oil, grease, paint, or other foreign material by sand blasting. Clean with vacuum type equipment to remove sand and other loose material.
      b. Broom clean and keep base slab wet for at least four hours before topping is applied.
      c. Use a thin coat of one part Portland cement, 1.5 parts fine sand, bonding admixture; and water at a 50: 50 ratio and mix to achieve the consistency of thick

paint. Apply to a damp base slab by scrubbing with a stiff fiber brush. New concrete shall be placed while the bonding grout is still tacky.

C. Conveying Concrete: Convey concrete from mixer to final place of deposit by a method which will prevent segregation. Method of conveying concrete subject to approval of Resident Engineer.

D. Placing: For special requirements see Paragraphs, HOT WEATHER and COLD WEATHER.

1. Do not place concrete when weather conditions prevent proper placement and consolidation, or when concrete has attained its initial set, or has contained its water or cement content more than 1 1/2 hours.
2. Deposit concrete in forms as near as practicable in its final position. Prevent splashing of forms or reinforcement with concrete in advance of placing concrete.
3. Do not drop concrete freely more than 10 feet for concrete containing the high-range water-reducing admixture (superplasticizer) or 5 feet for conventional concrete. Where greater drops are required, use a tremie or flexible spout (canvas elephant trunk), attached to a suitable hopper.
4. Discharge contents of tremies or flexible spouts in horizontal layers not exceeding 20 inches in thickness, and space tremies such as to provide a minimum of lateral movement of concrete.
5. Continuously place concrete until an entire unit between construction joints is placed. Rate and method of placing concrete shall be such that no concrete between construction joints will be deposited upon or against partly set concrete, after its initial set has taken place, or after 45 minutes of elapsed time during concrete placement.
6. On bottom of members with severe congestion of reinforcement, deposit 1 inch layer of flowing concrete containing the specified high-range water-reducing admixture (superplasticizer). Successive concrete lifts may be a continuation of this concrete or concrete with a conventional slump.
7. Concrete on metal deck:
    a. Concrete on metal deck shall be minimum thickness shown. Allow for deflection of steel beams and metal deck under the weight of wet concrete in calculating concrete quantities for slab.

1) The Contractor shall become familiar with deflection characteristics of structural frame to include proper amount of additional concrete due to beam/deck deflection.

E. Consolidation: Conform to ACI 309. Immediately after depositing, spade concrete next to forms, work around reinforcement and into angles of forms, tamp lightly by hand, and compact with mechanical vibrator applied directly into concrete at approximately 18 inch intervals. Mechanical vibrator shall be power driven, hand operated type with minimum frequency of 5000 cycles per minute having an intensity sufficient to cause flow or settlement of concrete into place. Vibrate concrete to produce thorough compaction, complete embedment of reinforcement and concrete of uniform and maximum density without segregation of mix. Do not transport concrete in forms by vibration.
   1. Use of form vibration shall be approved only when concrete sections are too thin or too inaccessible for use of internal vibration.
   2. Carry on vibration continuously with placing of concrete. Do not insert vibrator into concrete that has begun to set.

3.8 HOT WEATHER

Follow the recommendations of ACI 305 or as specified to prevent problems in the manufacturing, placing, and curing of concrete that can adversely affect the properties and serviceability of the hardened concrete. Methods proposed for cooling materials and arrangements for protecting concrete shall be made in advance of concrete placement and approved by Resident Engineer.

3.9 COLD WEATHER

Follow the recommendations of ACI 306 or as specified to prevent freezing of concrete and to permit concrete to gain strength properly. Use only the specified non-corrosive, non-chloride accelerator. Do not use calcium chloride, thiocyantes or admixtures containing more than 0.05 percent chloride ions. Methods proposed for heating materials and arrangements for protecting concrete shall be made in advance of concrete placement and approved by Resident Engineer.

3.10 PROTECTION AND CURING

A. Conform to ACI 308: Initial curing shall immediately follow the finishing operation. Protect exposed surfaces of concrete from premature drying, wash by rain and running water, wind, mechanical injury, and excessively hot or cold temperatures. Keep concrete not covered with membrane or other curing material continuously wet for at least 7 days

after placing, except wet curing period for high-early-strength concrete shall be not less than 3 days. Keep wood forms continuously wet to prevent moisture loss until forms are removed. Cure exposed concrete surfaces as described below. Other curing methods may be used if approved by Resident Engineer.

1. Liquid curing and sealing compounds: Apply by power-driven spray or roller in accordance with the manufacturer's instructions. Apply immediately after finishing. Maximum coverage 400 square feet per gallon on steel troweled surfaces and 300 square feet per gallon on floated or broomed surfaces for the curing/sealing compound.
2. Plastic sheets: Apply as soon as concrete has hardened sufficiently to prevent surface damage. Utilize widest practical width sheet and overlap adjacent sheets 2 inches. Tightly seal joints with tape.
3. Paper: Utilize widest practical width paper and overlap adjacent sheets 2 inches. Tightly seal joints with sand, wood planks, pressure-sensitive tape, mastic or glue.

3.11 REMOVAL OF FORMS

A. Remove in a manner to assure complete safety of structure after the following conditions have been met.
   1. Where structure as a whole is supported on shores, forms for beams and girder sides, columns, and similar vertical structural members may be removed after 24 hours, provided concrete has hardened sufficiently to prevent surface damage and curing is continued without any lapse in time as specified for exposed surfaces.
   2. Take particular care in removing forms of architectural exposed concrete to insure surfaces are not marred or gouged, and that corners and arises are true, sharp and unbroken.
B. Reshoring: Reshoring is required if superimposed load plus dead load of the floor exceeds the capacity of the floor at the time of loading. Reshoring accomplished in accordance with ACI 347 at no additional cost to the Government.

3.12 CONCRETE SURFACE PREPARATION

A. Metal Removal: Unnecessary metal items cut back flush with face of concrete members.
B. Patching: Maintain curing and start patching as soon as forms are removed. Do not apply curing compounds to concrete surfaces requiring patching until patching is completed. Use cement mortar for patching of same composition as that used in concrete. Use white or gray Portland cement as necessary to obtain finish color

matching surrounding concrete. Thoroughly clean areas to be patched. Cut out honeycombed or otherwise defective areas to solid concrete to a depth of not less than 1 inch. Cut edge perpendicular to surface of concrete. Saturate with water area to be patched, and at least 6 inches surrounding before placing patching mortar. Give area to be patched a brush coat of cement grout followed immediately by patching mortar. Cement grout composed of one part Portland cement, 1.5 parts fine sand, bonding admixture, and water at a 50:50 ratio, mix to achieve consistency of thick paint. Mix patching mortar approximately 1 hour before placing and remix occasionally during this period without addition of water. Compact mortar into place and screed slightly higher than surrounding surface. After initial shrinkage has occurred, finish to match color and texture of adjoining surfaces. Cure patches as specified for other concrete. Fill form tie holes which extend entirely through walls from unexposed face by means of a pressure gun or other suitable device to force mortar through wall. Wipe excess mortar off exposed face with a cloth.

C. Upon removal of forms, clean vertical concrete surface that is to receive bonded applied cementitious application with wire brushes or by sand blasting to remove unset material, laitance, and loose particles to expose aggregates to provide a clean, firm, granular surface for bond of applied finish.
D. For exposed surfaces of concrete for the columbarium and memorial walls and walls in their complexes, follow the procedures identified in Paragraph 3.12.A.3.
E. For columbarium and memorial walls and their complexes, immediately after forms are removed, take steps to prepare and smooth the exposed portions of the concrete. Remove the form marks, including joint marks, fins, burrs and similar projections to produce a smooth surface. Complete the surface finish to result in a uniform textured surface with homogeneous color, unless surface is to be otherwise treated. Work must be as approved during the review of the mock-up.

3.13 CONCRETE FINISHES

A. Vertical and Overhead Surface Finishes:
    1. Unfinished areas: Vertical and overhead concrete surfaces exposed in pipe basements, elevator and dumbwaiter shafts, pipe spaces, pipe trenches, above suspended ceilings, manholes, and other unfinished areas will not require additional finishing.
    2. Interior and exterior exposed areas to be painted: Remove fins, burrs and similar projections on surfaces flush, and smooth by mechanical means approved by

Resident Engineer, and by rubbing lightly with a fine abrasive stone or hone. Use ample water during rubbing without working up a lather of mortar or changing texture of concrete.

3. Interior and exterior exposed areas finished: Give a grout finish of uniform color and smooth finish treated as follows:
   a. After concrete has hardened and laitance, fins and burrs removed, scrub concrete with wire brushes. Clean stained concrete surfaces by use of a hone stone.
   b. Apply grout composed of one part of Portland cement, one part fine sand, smaller than a 600 µm (No. 30) sieve. Work grout into surface of concrete with cork floats or fiber brushes until all pits, and honeycombs are filled.
   c. After grout has hardened slightly, but while still plastic, scrape grout off with a sponge rubber float and, about 1 hour later, rub concrete vigorously with burlap to remove any excess grout remaining on surfaces.
   d. In hot, dry weather use a fog spray to keep grout wet during setting period. Complete finish of area in same day. Make limits of finished areas at natural breaks in wall surface. Leave no grout on concrete surface overnight.
4. Textured: Finish as specified. Maximum quantity of patched area 2 square feet in each 1000 square feet of textured surface.

B. Slab Finishes:
   1. Monitoring and Adjustment: Provide continuous cycle of placement, measurement, evaluation and adjustment of procedures to produce slabs within specified tolerances. Provide information to Resident Engineer and floor consultant for evaluation and recommendations for subsequent placements.
   2. Set perimeter forms to serve as screed using either optical or laser instruments. For slabs on grade, wet screeds may be used to establish initial grade during strike-off, unless Resident Engineer determines that the method is proving insufficient to meet required finish tolerances and directs use of rigid screed guides. Where wet screeds are allowed, they shall be placed using grade stakes set by optical or laser instruments. Use rigid screed guides, as opposed to wet screeds, to control strike-off elevation for all types of elevated (non slab-on-grade) slabs. Divide bays into halves or thirds by hard screeds. Adjust as necessary where monitoring of previous placements indicates unshored structural steel deflections to other than a level profile.

3. Place slabs monolithically. Once slab placement commences, complete finishing operations within same day. Slope finished slab to floor drains where they occur, whether shown or not.
4. Use straightedges specifically made for screeding, such as hollow magnesium straightedges or power strike-offs. Do not use pieces of dimensioned lumber. Strike off and screed slab to a true surface at required elevations. Use optical or laser instruments to check concrete finished surface grade after strike-off. Repeat strike-off as necessary. Complete screeding before any excess moisture or bleeding water is present on surface. Do not sprinkle dry cement on the surface.
5. Immediately following screeding, and before any bleed water appears, use a 10 foot wide highway straightedge in a cutting and filling operation to achieve surface flatness. Do not use bull floats or darbys, except that darbying may be allowed for narrow slabs and restricted spaces.
6. Wait until water sheen disappears and surface stiffens before proceeding further. Do not perform subsequent operations until concrete will sustain foot pressure with maximum of 1/4 inch indentation.
7. Scratch Finish: Finish base slab to receive a bonded applied cementitious application as indicated above, except that bull floats and darbys may be used. Thoroughly coarse wire broom within two hours after placing to roughen slab surface to insure a permanent bond between base slab and applied materials.
8. Float Finish: Slabs to receive unbonded toppings, steel trowel finish, fill, mortar setting beds, or a built-up roof, and ramps, stair treads, platforms (interior and exterior), and equipment pads shall be floated to a smooth, dense uniform, sandy textured finish. During floating, while surface is still soft, check surface for flatness using a 10 foot highway straightedge. Correct high spots by cutting down and correct low spots by filling in with material of same composition as floor finish. Remove any surface projections and re-float to a uniform texture.
9. Steel Trowel Finish: Concrete surfaces to receive resilient floor covering or carpet, monolithic floor slabs to be exposed to view in finished work, future floor roof slabs, applied toppings, and other interior surfaces for which no other finish is indicated. Steel trowel immediately following floating. During final troweling, tilt steel trowel at a slight angle and exert heavy pressure to compact cement paste and form a dense, smooth surface. Finished surface shall be smooth, free of trowel marks, and uniform in texture and appearance.

10. Broom Finish: Finish exterior slabs, ramps, and stair treads with a bristle brush moistened with clear water after surfaces have been floated. Brush in a direction transverse to main traffic. Match texture approved by Resident Engineer from sample panel.
11. Finished slab flatness (FF) and levelness (FL) values comply with the following minimum requirements:
    a. Areas covered with carpeting, or not specified otherwise in b. below:
       Slab on Grade:

Specified overall value	F_F 25/F_L 20
Minimum local value	F_F 17/F_L 15
Specified overall value	FF 25
Minimum local value	FF 17

       Level tolerance such that 80 percent of all points fall within a 3/4 inch envelope +3/8 inch, -3/8 inch from the design elevation.
    b. Areas that will be exposed, receive thin-set tile or resilient flooring, or roof areas designed as future floors:
       Slab on grade:

Specified overall value	FF 36/FL 20

       Level tolerance such that 80 percent of all points fall within a 3/4 inch envelope +3/8 inch, -3/8 inch from the design elevation.
    c. "Specified overall value" is based on the composite of all measured values in a placement derived in accordance with ASTM E1155.
    d. "Minimum local value" (MLV) describes the flatness or levelness below which repair or replacement is required. MLV is based on the results of an individual placement and applies to a minimum local area. Minimum local area boundaries may not cross a construction joint or expansion joint. A minimum local area will be bounded by construction and/or control joints, or by column lines and/or half-column lines, whichever is smaller.
12. Measurements
    a. Department of Veterans Affairs retained testing laboratory will take measurements as directed by Resident Engineer, to verify compliance with F_F, F_L, and other finish requirements. Measurements will occur within 72 hours after completion of concrete placement (weekends and holidays excluded). Make measurements before shores or forms are removed to insure the "as-built"

levelness is accurately assessed. Profile data for above characteristics may be collected using a laser level or any Type II apparatus (ASTM E1155, "profileograph" or "dipstick"). Contractor's surveyor shall establish reference elevations to be used by Department of Veterans Affairs retained testing laboratory.

b. Contractor not experienced in using F_F and F_L criteria is encouraged to retain the services of a floor consultant to assist with recommendations concerning adjustments to slab thicknesses, finishing techniques, and procedures on measurements of the finish as it progresses in order to achieve the specific flatness and levelness numbers.

13. Acceptance/ Rejection:
    a. If individual slab section measures less than either of specified minimum local F_F/F_L numbers, that section shall be rejected and remedial measures shall be required. Sectional boundaries may be set at construction and contraction (control) joints, and not smaller than one-half bay.
    b. If composite value of entire slab installation, combination of all local results, measures less than either of specified overall F_F/F_L numbers, then whole slab shall be rejected and remedial measures shall be required.
14. Remedial Measures for Rejected Slabs: Correct rejected slab areas by grinding, planeing, surface repair with underlayment compound or repair topping, re-topping, or removal and replacement of entire rejected slab areas, as directed by Resident Engineer, until a slab finish constructed within specified tolerances is accepted.

3.14 SURFACE TREATMENTS

A. Mix and apply surface treatments in accordance with manufacturer's printed instructions.
B. Liquid Densifier/Sealer: Use on all exposed concrete floors and concrete floors to receive carpeting, except those specified to receive non-slip finish.
C. Non-Slip Finish: Except where safety nosing and tread coverings are shown, apply non-slip abrasive aggregate to treads and platforms of all concrete steps and stairs, and to surfaces of exterior concrete ramps and platforms. Broadcast aggregate uniformly over concrete surface. Trowel concrete surface to smooth dense finish. After curing, rub the treated surface with abrasive brick and water sufficiently to slightly expose abrasive aggregate.

3.15 APPLIED TOPPING

A. Separate concrete topping on floor base slab of thickness and strength shown. Topping mix shall have a maximum slump of 8 inches for concrete containing a high-range water-reducing admixture (superplasticizer) and 4 inches for conventional mix. Neatly bevel or slope at door openings and at slabs adjoining spaces not receiving an applied finish.

B. Placing: Place continuously until entire section is complete, struck off with straightedge, leveled with a highway straightedge or highway bull float, floated and troweled by machine to a hard dense finish. Slope to floor drains as required. Do not start floating until free water has disappeared and no water sheen is visible. Allow drying of surface moisture naturally. Do not hasten by "dusting" with cement or sand.

3.16 PRECAST CONCRETE ITEMS

A. Cast precast concrete items, not specified elsewhere, using 4000 psi air-entrained concrete to shapes and dimensions shown. Finish surfaces to match corresponding adjacent concrete surfaces. Reinforce with steel as necessary for safe handling and erection.

- - - E N D - - -

SECTION 03 48 21
PRECAST CONCRETE BURIAL CRYPTS
(DOUBLE DEPTH LAWN CRYPT)

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes furnishing and installation of precast concrete burial crypts as shown on the Drawings and specified, including but not limited to the following:

1. Fabricate
2. Transport and deliver to site
3. Unload units on dunnage or gravel
4. Store and/or install precast concrete burial crypts (units or crypts)
5. Install subbase foundation and drainage
6. Install units in the prepared crypt fields
7. Backfill between and around the crypts
8. Install sand and/or backfill on top of crypts
9. Compact fill materials
10. Place topsoil
11. Provide additional Materials:
    a. Three (3) OSHA -approved crypt lid lifting apparatuses
    b. Five (5) extra concrete crypt lids
    c. A device to easily retrieve and lower the inside shelf by one man without entering the crypt.
12. Other Associated Work

1.2 DESIGN OVERVIEW

A. The design of the units shall be as described in this Section and their installation layout shall be as indicated on the Drawings. Design requirements shall be as follows:

1. All perimeter crypts shall be structurally designed for overhead and lateral soil pressure plus live loads specified hereafter.
2. All designs will require that the manufacturer provide fabrication drawings stamped by a Professional Engineer registered in the State of Tennessee, indicating that the design meets or exceeds the structural requirements contained herein.
3. Alternative crypt component designs may be proposed if all the following requirements are met:
    a. Comply with the design criteria and the functional tests of this specification.
    b. All provisions of this specification shall apply to any proposed alternative design.

c. The NCA may accept or reject part or all of any proposed alternative design. The Contractor shall pay all costs for alternate designs, submittals, and reviews.

1.3 RELATED WORK

A. Section 31 20 00 - EARTH MOVING.

B. Section 01 45 29 - TESTING LABORATORY SERVICES.

1.4 QUALITY ASSURANCE

A. Manufacturer's Qualifications: As part of the bid, Contractor shall submit documentation regarding the manufacture of the units. Provide evidence that manufacturer has a minimum of three years of experience with pre-casting units of similar type. Current plant certification for the location(s) that will be producing units for this project from the National Precast Concrete Association (NPCA) shall be provided as a submittal prior to any work being performed.

B. Provide a written stamped certification from a licensed Structural Engineer that certifies that the units being manufactured conform to the specified design and performance requirements.

C. Installation Qualifications: Provide written documentation that indicates the installer has been regularly engaged, for at least three years, in installation of pre-cast concrete similar to the units required for this project.

D. Fabricate crypts to the interior dimensions specified in this Section and shown on the Drawings. Replace or repair units that do not comply with the individual dimensions and tolerances.

E. Prior to, or in the initial stage of crypt production, furnish at the site: proposed shelf removal tool; two perimeter crypts; and one interior crypt. The three crypts shall be the basis for determination of acceptable quality of construction and be used for on-site buried crypt functional load testing as described in this Section.

F. Functional Load Tests: Functional on-site load tests shall be made at the Contractor's expense to insure that the units are capable of supporting loads stated. The functional tests shall consist of the following:

1. Confined Loading: An interior unit between two perimeter units shall be placed in a hole dug in the ground on site and covered with 24 inches of soil or covered to the maximum depth as shown on the Drawings, whichever is greater. The soil shall be compacted to 95 percent of the material's maximum dry density (as determined using ASTM D698) along the sides (and reduced density over the lid), both as shown on the Drawings. An axle load of 12,000 pounds shall be passed over the covered

crypts for a minimum of 10 times in repetition, in a manner that causes maximum lateral pressure due to wheel load on the sides of the crypts. The crypts shall then be fully excavated and exposed, and the lids shall be removed to allow careful examination inside and outside. The crypts shall not show any signs of stress or cracking.

2. Shelf Load Testing (for the inside shelf) shall be as follows:
   a. Apply load to individual support struts. Use one worker with a minimum weight of 200 pounds. Worker shall carefully walk on individual supports to confirm structural integrity and load bearing capability. Worker shall adhere to all safety regulations while performing test.
   b. Upon completion of shelf load testing, the inside shelf shall be removed by the removal tool as follows:
      1) Without entering the crypt and by one man.
      2) Inspected, and lowered back into the crypt in the second interment position.
      3) The inside shelf shall not show any signs of stress, cracking or deflection.
   c. Demonstrate the removal and replacement process for the inside shelf. The functioning of the shelf removal tool shall be approved by the NCA Crypt Specialist.

G. Commence production of crypts only after the written submittal(s) are approved and acceptable on-site load testing and demonstration have been scheduled for witnessing by the NCA Crypt Specialist.

1.5 DESIGN CRITERIA

A. Design Criteria (Double Depth Crypt): All design calculations and drawings shall be signed and sealed by qualified licensed Structural Engineer in the State of Tennessee.
   1. The units shall be of the following type, style, and size:
      a. Type: Precast concrete.
      b. Style: One-piece box with separate outer lid and the following:
         1) A removable one-piece inside shelf
         2) Four casket risers or two casket support bars
         3) Drain Holes 4-inch diameter in the floor bottom. Two drain holes shall be provided at opposite ends when there are casket risers. Three drain holes shall be provided at opposite ends and in middle, when there are two support bars.
      c. Crypt interior size: Interior minimum dimensions shall be as follows:

1) 30-inch minimum width at the inside bottom floor and for the full height of the crypt
2) 86-inch minimum length along the inside bottom floor and for the full height of the crypt
3) 25-inch minimum clear height from the highest part of the inside shelf to the underside of the lid
4) 25-inch minimum clear height from the lowest part of the inside shelf to the top of the casket risers
5) 3/4-inch minimum height casket risers from the crypt floor spaced 20 inches from crypt centerline to eliminate pinching of the lowering straps during removal. Four risers are required.

d. Crypt height and wall thickness:
1) Exterior maximum height dimension: 60 inches, including the lid.
2) Crypt wall thickness: two inches (with a tolerance of minus 1/2 inch) for inside shelf bearing.
3) Perimeter crypts are allowed thicker walls where additional reinforcing is included.
4) Crypt wall sections at support slots originated from the top for the inside shelf may be of lesser thickness.

e. Layout:
1) Crypts shall fit in a 3-foot by 8-foot nominal plot size or a lesser plot size as noted on the Drawings.
2) The lesser plot size shall govern. If the proposed crypts do not fit into the designed or indicated plot size, with adequate room for the between crypt backfill, or if a different plot size is suggested, the Contractor, at no cost to the NCA, shall prepare a revised Layout/Size Plan and submit it for review and approval by the COTR.

2. Load Conditions for design of units shall be as follows:
a. A burial depth with soil cover as indicated on the Drawings.
b. A center point load of 6,000 pounds on one square foot, prior to burial.
c. Passage of a wheel axle load of 12,000 pounds after burial.
d. A three-foot tall pile of excavated material on top of or adjacent to buried crypts.

B. Design Criteria (Concrete Lids):
1. Removable and replaceable.

2. Lid lifting shall be from top positioned hot-dipped galvanized anchors (four required per lid) with removable anchor covers to prevent dirt from entering the anchor bowl and installed in such a manner as to stay in-place when excavating equipment is scraping backfill off the top of the lid. Furnish the cemetery with three (OSHA approved and tag certified wire rope lifting devices for removing the lid. No chain lifting devices allowed.

C. Design Criteria (Inside shelf):
   1. One piece rigid construction
   2. Fully conceal the lower casket with a rigid barrier
   3. Weigh 40 pounds or less
   4. Allow for easy casket lowering belt removal
   5. Capable of holding 400 pounds indefinitely.
   6. The entire inside shelf should be rigid, non-brittle, non-deteriorating, and have a maximum 1/4 inch gap from all shelf edges to the crypt wall to create a visual barrier.
   7. Have one lifting hole (3/4-inch maximum diameter) in the middle about two inches from the edge.

D. Design Criteria (Inside Shelf Removal Tools):
   1. Constructed so one man can easily retrieve and install the shelf from ground level without entering the crypt. Demonstrate the use and functionality of said tool at the crypt buried load testing, for the conditions that will occur at the cemetery during the interments at the crypt sections(s).

E. Design Criteria (Quad Crypt):
   1. An alternate concrete Quad unit (one piece) may be used as an approved equal in lieu of two double depth lawn crypt units. The Quad units shall conform to all other specified herein including:
      a. The shared interior concrete wall thickness may be increased to allow for a gap between lids as deemed appropriate to meet layout requirements.

F. Miscellaneous Manufacturing Requirements:
   1. The concrete lid shall be beveled along the entire top perimeter. Chamfer top edge of lid with a 1:1 chamfer beginning 1/2 inch down from top.
   2. The design of casket risers, whether individual spots or bars crossing the bottom, shall allow the casket to rest a minimum of 3/4 inch above the inside floor of the crypt and above the top of the inside shelf in order to aid in casket lowering straps removal. In addition, rests location shall not exceed 21 inches from crypt centerline.

3. The crypt outside lifting wire shall be designed for transport and installation along with provisions for removal/abandonment of crypt lifting wire once crypt has been installed.

1.6 ALLOWABLE TOLERANCES

A. Tolerances of individual units shall be as follows:
   1. Variation in overall crypt outside dimensions of unit (height, length and width): 1/8 inch plus or minus. There is zero tolerance for any lesser crypt inside minimum clear dimensions.
   2. Variation in thickness of precast panels and elements: 11/16 inch plus or minus.
   3. Maximum height differential in final placement in the ground: 1/4 inch above or below design grade.
   4. Cracks greater than 0.030 inch width are cause for crypt rejection. With evidence of fiber or steel reinforcement, any cracking 0.030 inch or lesser width that does not extend thru wall is acceptable. Any cracking 0.016 inch or lesser that extends thru wall is acceptable. All other cracks are cause for rejecting crypts that shall be repaired or removed and replaced at no cost to the NCA.

1.7 SUBMITTALS

A. Submit the following in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES

B. Samples:
   1. Submit within 45 days of the approval of the shop drawings for review and approval by the COTR and NCA Crypt Specialist.
   2. Deliver to the site for testing and inspection.
   3. Submit samples of: two perimeter crypts and one interior crypt.

C. Manufacturer's qualifications as specified in 1.6 of this Section.

D. Detailed Concrete Mix Design of Self Consolidating Concrete (SCC) with a 15 percent minimum requirement of a cement substitute of fly ash and/or other pozzalons.

E. Shop Drawings:
   1. Installation Narrative:
      a. Method of transportation.
      b. Method of handling and placement.
   2. Production Drawings:
      a. Elevation view of each unit.
      b. Plan view of unit.

c. Sections and details to show quantities, sizes and position of reinforcing steel, inserts, and essential embedded hardware for fabrication, handling, transportation and installation.
d. Section, details and location of specialty lid lifting anchors, caps, and lid lifting system.
e. Dimensions and finishes.

F. Product Design Data:
1. Structural adequacy calculations of units (crypts), performed by a licensed Structural Engineer.
2. Loadings for Design Calculations:
a. Initial handling and erection stresses.
b. Dead and live loads specified.
c. Other loads specified for units as applicable.
d. Deflection of precast members.
e. Product test reports:
1) The concrete shall be tested for the compressive strength and beam flexural strength as specified herein. An approved independent, commercial testing laboratory shall perform tests. Certified copies of test reports, including test data and results shall be submitted to the COTR immediately after the strength tests have been completed. The tests shall be as specified herein.
2) Prior to backfilling over crypts and at contractor expense, the COTR may pick a single crypt for coring another bottom slab drainage hole by an independent lab with said core being analyzed (petrography testing) and results submitted verifying evidence of fly ash or other pozzalons as specified.
3) Based on failed testing, the COTR may request more frequent testing to ensure quality of the product and pozzalons content is present, again at contractor expense.
3. Manufacturer's Literature and Data:
a. Each type of anchorage, angle, and fastener.

G. Design Documentation:
1. The Contractor shall submit five sets of design documentation showing structural design of the units. Contractor shall provide one additional set to the NCA Crypt Specialist. This documentation shall include dimensions, methods of construction, and calculations.

2. The Structural Engineer that stamps the design calculations and drawings shall provide:
    a. Written recommendations indicating the extent of voids that are allowable in the produced units, without causing any degradation of loading capacity from the design load values.
    b. Written recommendations on the conditions where repairs will be allowed, and materials and methods to be used for repairs.
    c. Written statement that all repairs to the units shall only be allowed if they are performed according to the written recommendations of the Structural Engineer.

H. At completion of the work, submit documentation specified in 3.8 of this Section.

1.8 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Delivery and Handling: Units shall be transported, stored and handled so as to prevent damage to surfaces, edges and corners and to prevent development of stresses and cracks. Provide temporary bracing protection devices and measures as necessary to prevent damage to the units during handling, transportation and storage. Transportation, storage and handling of units without damage is required. Any damage caused by accident or negligence on the Contractor's part shall be corrected at the Contractor's expense. Use the designed crypt lifting wire system to transport crypts. On the project site, forklift handling of crypts may be approved by the COTR only following:
    1. Verification that the structural design is adequate.
    2. Verification by the manufacturer and demonstration that the field procedures will cause no crypt damage.
    3. Submission of written safety procedures to be followed so the procedure is maintained as SAFE.

B. Storage:
    1. Units may be stored within crypt fields being constructed on gravel, or at other designated locations(s) on site, as long as they are set on blocking, gravel or other approved methods to prevent damage or plugging of the bottom drainage holes.

C. Markings and Identifications:
    1. Markings, including logos, trademarks and proprietary information are prohibited on surfaces of crypts.
    2. Date of manufacture (month, day, and year) shall be written on the box and lid with permanent ink or an equivalent marking.

1.9 COORDINATION

A. Coordinate the manufacture, delivery, storage and installation of the units with related work.

1.10 GUARANTEE

A. After erection, completed work shall be subject to terms of the Contract, except guarantee period is extended to five years.

1.11 APPLICABLE PUBLICATIONS

A. Publications listed below form a part of this specification to extent referenced. Publications are referenced in text by the basic designation only.Comply with the latest edition of all referenced publications unless otherwise specified.

C. American Concrete Institute (ACI):

ACI Manual of Concrete Practice 2011 Edition.

ACI 318	Building Code Requirements for Structural Concrete

D. ASTM International (ASTM):

A36/A36M	Standard Specification for Carbon Structural Steel.
A153/A153M	Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware.
A615/A615M	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
A1064/A1064M	Standard Specification for Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
C31/C31M	Standard Practice for Making and Curing Concrete Test Specimens in the Field.
C33/C33M	Standard Specification for Concrete Aggregates
C39/C39M	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimen
C78/C78M	Standard Test Method for Flexural Strength for Concrete (Using Simple Beam with Third-Point Loading)
C150/C150M	Standard Specification for Portland Cement.
C172/C172M	Standard Practice for Sampling Freshly Mixed Concrete.
C260/C260M	Standard Specification for Air-Training Admixtures for Concrete.
C494/C494M	Standard Specification for Chemical Admixtures for Concrete

C595/C595	Standard Specification for Blended Hydraulic Cement.
C1017/C1017M	Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete.
C1116/C1116M	Standard Specification for Fiber-Reinforced Concrete.
C1157/C1157M	Standard Performance Specification for Hydraulic Cement
C1399/C1399M	Standard Test Methods for Obtaining Residual-Strength of Fiber-Reinforced Concrete.
C1602/C1602M	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete.
D 698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort

PART 2 - PRODUCTS

2.1 CRYPT MATERIALS

A. Precast Concrete: All crypts shall be constructed of concrete and conform to the following specifications:
   1. A minimum 28 days compressive strength of 5,000 psi
   2. Self-Consolidating Concrete (SCC) containing structural fiber with an inverted slump between 22 inches and 28 inches
   3. Shall contain a minimum of 15 percent cement substitute of fly ash and/or other pozzalons. Fiber is not required for crypt lids
   4. Hydraulic Cement: ASTM C150,ASTM C1157 or ASTM C595
   5. Normal weight Aggregates: ASTM C33
   6. Water: ASTM C1602
   7. Chemical Admixtures:
      a. Water reducers, accelerating and retarding: ASTM C494
      b. Air Entraining: ASTM C260
      c. Admixtures for flowing concrete: ASTM C1017
      d. Admixtures with no standard designation shall be used only with approval of the NCA.
   8. Prohibited Admixtures: Calcium Chloride thyocyanates or admixtures containing more than 0.1 percent chloride ions.

B. Reinforcement:
   1. Welded Steel Wire Fabric: ASTM A1064.
   2. Steel Reinforcement: ASTM A615 Grade 60, deformed.

4. Inserts, Anchors, Dowels and Accessories: Steel, ASTM A36, zinc coated ASTM A153 hot-dipped galvanized finish G90.
5. Fiber: Macrofiber complying with ASTM C1116

C. Form Coatings:
1. Use commercial formulation form-coating compounds that will not bond with, stain, or adversely affect concrete surfaces.

D. Paint:
1. Use commercial Concrete & Garage Floor Epoxy Acrylic Paint for crypt concrete lid and inside wall surface numbering. Paint shall be as manufactured by BEHR Deep Base #930 or approved equal. The use of an approved equivalent spray paint product, if approved by the NCA Crypt Specialist, shall only be for use on the interior crypt numbers.

2.2 FABRICATION

A. General:
1. Units shall be fabricated in accordance with the minimum interior dimensions and tolerances specified herein, with concrete surfaces that are smooth and free of irregularities.

B. Finishes:
1. Surface holes (1/4 inch and smaller) that are caused by air bubbles, normal color variations, normal form joint marks, small chips (1/4 inch) and smaller and spalling (no more than one square foot) total per unit are permitted.
2. Exposed steel reinforcing, honeycomb, bugholes, and cracks not within tolerances are not permitted.
3. The lid lifting system shall be as follows:
   a. Top mounted and consist of hot dip galvanized steel anchors (four per lid) each in a 2-1/2 inch diameter minimum recessed bowl of depth sufficient to easily connect lifting device as designated compatible by anchor manufacturer.
   b. Anchors shall be installed at locations to ensure maximum lid lifting stability.
   c. A removable plastic cap secured to the anchor so that fill material is prevented from entering the anchor bowl. Cap shall be flush mounted to ensure the entire assembly is not an obstruction for crypt excavating equipment.
4. Concrete shall have no evidence of segregation of materials.

C. Reinforcement:

1. Provide steel and fiber reinforcing as required for casting, handling, erection loads, lateral and overhead fill, and equipment live loads.
2. Reinforcing steel shall be free of dirt, mill scale, rust, oil, grease, ice, snow, water and placed within approved tolerances in accordance with ACI 318. Careful placement of reinforcing is required to avoid overlapping at thin points of the units.

D. Concrete Placement:
1. Porosity, strength, weight and gradation of coarse aggregate shall be as required to produce specified characteristics.
2. Units shall be cast in steel forms designed to suit shape and finish required. Each element of the unit shall be cast as an integral piece free of joints and seams.

E. Curing:
1. 75 percent of specified concrete compressive strength shall be attained before transportation of units to the cemetery or storage site.
2. Units shall be cured as required to develop specified structural characteristics and shall be stored in a manner that will permit all surfaces to cure equally.
3. Units shall be properly cured in accordance with the applicable provisions of the current ACI Manual of Concrete Practice.

F. Surface Treatment and Corrective Work:
1. Units that have minor chipping of edges and corners shall be repaired by a method approved by the COTR.
2. Cracked/damaged units exceeding tolerances shall be removed by the contractor at no cost to the NCA.
3. Any corrective work beyond what the COTR determines is minor, shall be handled according to written procedures from the Structural Engineer that stamped the design for the units. Otherwise, the units shall be removed and replaced.

2.4 BACKFILL MATERIAL

A. Backfill between the crypts where gap is less than two inches shall be an approved rounded gravel (pea gravel) conforming to the gradation indicated in the following table.

Aggregate Size No.	Grading Requirements - Amounts finer than Each Sieve (Square Openings), Mass Percent					
	(1/2")	**(3/8")**	**(No. 4)**	**(No. 8)**	**(No. 16)**	**(No.50)**
8	100	85 to 100	10 to 30	0 to 10	0 to 5	
89	100	90 to 100	20 to 55	5 to 30	0 to 10	0 to 5

1. At COTR's discretion, a non-rounded stone may be considered as a substitute for the rounded stone. The COTR may accept the (non-rounded) stone only following demonstration, through an approved submittal process, that rounded stone is not available for less than four times the cost of a cut/crushed angular (non-rounded) aggregate substitute. Largest size for the non-rounded stones shall not exceed the gradation size for the rounded stones. (A smaller gradation size will be required for the non-rounded stones to insure that the stones are not larger that their rounded counterparts.) The non-rounded stone shall only be considered when with the largest size of the stone passing a sieve size does not exceed the allowable stone size for the rounded stone gradations. The non-rounded stone may be approved when the size is as described above, and with a successful demonstration that filling gaps between crypts leaves no voids, because the stones fall into place without bridging as should occur when using rounded stones.
2. No sand is allowed.

2.3 TESTING AND INSPECTION

A. Contractor's Responsibility for Inspection: The Contractor is responsible for the performance of all inspection requirements including:
   1. Removal of lids
   2. Number painting inside crypts
   3. Replacement of the lids for inspection by the COTR.
B. The COTR reserves the right to perform any of the inspections set forth in this Section when deemed necessary to assure that the units conform to prescribed requirements.

PART 3 - EXECUTION

3.1 CRYPT FIELD QUALITY ASSURANCE

A. Testing: The Contractor shall procure an independent qualified testing agency to perform concrete tests during crypt production and prepare test reports.
   1. Concrete Cylinder testing for compressive strength:
      a. Three cylinders per day of crypt production shall be taken in accordance to ASTM C172 as applicable to SCC.
      b. Strength shall exceed 5000 psi after 28 days curing in accordance to ASTM C31 and C39.
      c. Test inverted slump when cylinders are made.
   2. Beam testing to confirm design flexure strength:

a. Once at the beginning of crypt production, a minimum of three beams with fiber shall be taken for testing of Flexural Performance of Fiber-Reinforced Concrete in accordance with ASTM C78 and C1399. All beams' flexural strength shall exceed the crypt design flexural strength requirements and residual strength of fiber reinforced concrete, and shall exceed capacity of conventionally reinforced concrete wall design as submitted by the Structural Engineer and approved by the NCA. Fiber Manufacturer shall verify type and dosage rate of the test beams are identical in crypt production.

3. A single verification test of fly ash in the crypt concrete mix required at the discretion of the COTR.

3.2 GENERAL LAYOUT CONTROL

A. A professional registered Land Surveyor shall establish sufficient lines, grades and control for the horizontal placement, slope of the base and top, and vertical alignment for the sides of units in accordance with the design drawings.

3.3 PREPARATION

A. Before beginning installation, inspect work of other trades insofar as it affects the work of this section. Commencing installation of units shall be construed as accepting as suitable the work of other trades.

B. Verify by survey, rough grading of aggregate for first row of crypts to be installed in a field. Provide a certification by the professional surveyor to the COTR that the rough grading for the base stone for the first row of crypts to be installed, as well as that the survey control points for crypt setting have been set according to the plans, prior to the Contractor starting to set crypts in the field. The Surveyor shall indicate to the COTR where the control points are located and how they are protected.

C. Verify by testing, compaction of prepared subgrade and subbase to meet specified compaction.

D. Verify by survey locations and elevations of units relative to control points indicated on the Drawings. Submit new control point layout if a crypt size other than specified is used.

3.4 HANDLING, INSTALLATION AND PAINTING

A. Handling:

1. Units shall be handled in a vertical plane at all times and stacked vertically on wood supports of adequate strength, or placed on gravel until erected. Use of approved

designed OEM lifting cable system that has been deemed to be safe for handling the units shall be used during the setting process, where workers are nearby.

2. Lift units with suitable lifting devices at points provided by manufacturer.
3. Provide temporary wood bracing to comply with manufacturer's recommendations to keep crypt bottom off ground during storage.

B. Installation and Painting:

1. Install units by competent erector crews trained and certified as competent by units manufacturer.
2. Use all means necessary to protect units from being damaged in transport and during and after installation. Lids or other parts of the crypt that show damage from bouncing during transport shall be replaced by the Contractor at no cost to the NCA.
3. Accurately install by aligning and leveling units in accordance with plans. Assure that crypts are in straight horizontal alignment.
4. After crypt installation and prior to backfill, remove lids with the specified lifting apparatus for crypt inspection by the COTR inspector and numbering. Numbers furnished by the NCA shall be painted on the outside of the crypt lids and on the upper inside crypt short wall, both at the headstone end. Numbers shall be permanent paint as specified and approximately twelve inches high. Crypt lid number painting must be applied to a clean, dust-free surface requiring paint application within 10 seconds of surface cleaning. After completion of inspection and marking, the Contractor shall replace the lids. Any damage to lids or crypts shall be the responsibility of the Contractor.

3.5 PROTECTION OF WORK

A. Use all means necessary to protect units from being damaged during and after installation.

3.6 REPLACEMENT AND REPAIR

A. Remove and replace units that the COTR has determined are damaged, cracked beyond tolerances, broken, improperly fabricated, or otherwise defective and are structurally unsound and unacceptable.
B. Units having minor defects not affecting serviceability or appearance may be repaired when approved by the COTR.
C. Proposed repair work shall be sound, permanent, and flush with adjacent surfaces and submitted for approval by the NCA Crypt Specialist.
D. Replacements and repairs shall be done at no additional cost to the NCA.

3.7 BACKFILLING AND CRYPT FIELD PROTECTION

A. Prior to the backfill being placed between the crypts, a professional Registered Land Surveyor shall:
   1. Survey the in-place crypts and provide a written certification that they are, within allowable tolerances, installed:
      a. At the design locations
      b. Properly aligned
      c. At correct elevations and slopes
B. The following documents shall be provided to the COTR:
   1. An electronic drawing of the as-built conditions for the installed crypts.
   2. A paper copy at appropriate scale so the crypt field is fully shown on a maximum sheet size of 24 inches by 36 inches with all indications of variances in the placement from the design drawings shown.
   3. A written certification that during the manufacturing, handling, setting, and or crypt numbering process that each of the lifting bowls were operated using the designed lifting device, and that any excessive concrete debris has been removed to allow free operation of the lifting bowls. A description of when in the process each of the lifting bowls were used shall also be provided.
C. When all of the crypts in a specific field are installed as indicated in the design drawings and details, and the surveyor has so certified, the COTR will approve the Contractor proceeding with the backfill between the crypts. The Contractor is responsible for insuring that the crypts do not move during the backfill operations, including but not limited to providing adequate blocking at the base of the units, if deemed necessary, to prevent them from moving during the backfill operations.
D. Protect installed crypt units during backfill operations.
E. Install approved backfill against outside walls of all units, insuring no voids are remaining. Approved backfill shall:
   1. Contain no materials that will cause a concentrated point load.
   2. The perimeter wall backfill shall be compacted to a minimum of 95 percent of the material's maximum dry density (as determined using ASTM D 698) to the elevation of the top of the crypts.
   3. Be compacted without using large vibratory equipment near crypts as impact loading may cause damage or failure of the crypt.
F. Backfill between the crypts where gap is less than two inches shall be as follows:

1. Install approved rounded gravel that meets the specified gradation into gaps between crypts leaving no voids.
2. Use rodding to assure no bridging occurs and void areas are eliminated.
3. As a resource saving measure, the use of angular stone of suitable gradation (typically the same stone used as drainage stone for below the crypts) shall be allowed in the space between the head and foot of the crypts only, if the Contractor demonstrates a successful method of placement that prevents the larger angular stone from spreading into the gaps along the long sides of side by side crypts.

G. Install backfill on top of units and compact. Backfill shall be as shown on the Drawings. In absence of Drawing details, backfill on top of units working from bottom up shall consist of: two inches of identification sand; soil to specified level; and four inches minimum of topsoil as the final layer. The entire backfill atop units shall be compacted to 85 percent of the material's maximum dry density (as determined using ASTM D 698.

H. Install drainage board for pea gravel flow containment located in perimeter crypt gaps in areas shown on Drawings.
   1. Drainage board shall be installed at the perimeter of crypt field in locations where standard or oversize traditional gravesite burial spaces are identified on the Drawings and other areas so designated.
   2. Drainage board shall be as appropriate to fill gap and stop pea gravel flow, and provide for drainage rates of 100 gallons per hour per linear foot in any direction.
   3. The drainage board shall be made of "non-deteriorating" recycled materials and be able to be compressed and return to its original thickness.
   4. Drainage board shall contain pea gravel between Crypts. Attach board to Crypt wall exterior with fastening method approved during functional load testing. Ensure board material re-expands to original thickness if compressed. Drainage board shall be installed from bottom of Crypt to bottom of lid. Exterior edge of board shall be inset at least two inches from edge of crypt and extend two feet in between Crypts.

I. No equipment over the crypts should exceed crypt design loads as specified in this Section (12,000 pounds axle load, including compacting equipment). No vibratory compaction equipment shall be allowed over or alongside crypts unless impact loads are shown not to exceed crypt design loads.

J. Immediately during crypts installation, mark the crypt field edges with temporary driven 5-foot tall lathes and signage for easy identification by vehicles carrying fill, topsoil,

compost, sod, water or other. Signage shall state *"12,000-lb axle load maximum. Keep 10 yards away"* and placed minimum 50 feet apart.

K. Lathes and signage shall be maintained in-place during backfilling thru final acceptance of the crypt field.

L. Finish grading and prepare topsoil as indicated on the Drawings.

M. Do not store or stockpile any stone, sand, backfill, crypts or any other material over four feet high within 10 yards of ground on top of installed crypts. Affected crypts subject to said loading condition as determined by the COTR shall be inspected for possible damages with all excavation, lid lifting, fill replacement and all other work as necessary, all at contractor's expense.

N. Do not allow any vehicle that exceeds a 12,000 pound axle load, 6000 pound wheel load or equivalent pressure per square inch to traverse or park within 10 yards of or on top of installed crypts. Affected crypts subject to said loading condition as determined by the COTR shall be inspected for possible damages with all excavation, lid lifting, fill replacement and all other work as necessary, all at contractor's expense.

3.8 INSPECTION AND ACCEPTANCE

A. Final inspection and acceptance will be by the COTR following receipt of:

1. Recommendations from the NCA Crypt Specialist.
2. Electronic DWG files of each individual crypt field, with coordinates of the monument markers indicated, and each burial plot being indicated with a closed polygon, and corresponding NCA burial plot identification number, along with the section markers and number for the section.

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