TECHNICAL SPECIFICATIONS FOR RICHARD A. HEYMAN ENVIRONMENTAL PROTECTION FACILITY – AERATION, SLUDGE CONVEYOR, AND EFFLUENT PUMP SYSTEM UPGRADES CITY OF KEY WEST PROJECT ID#: 199322

October 2019

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Date: 2019.12.20 15:12:45-06'00'

Florida Registered Professional Engineer No. 86809

Specifications: Divisions 3, 5

Structural

Section 01611

METEOROLOGICAL AND SEISMIC DESIGN CRITERIA

1. SCOPE. Buildings, non-structural components and non-building structures shall be designed in accordance with this section. In the event of conflict with requirements in other sections, the more stringent criteria shall be followed.

2. DESIGN CRITERIA. Buildings and, non-building structures including anchorage of such items, shall be designed in accordance with the following criteria.

General Design Data:

Building code and references

Florida Building Code, 6th Edition (2017)

IBC 2015 as amended by the Florida Bldg Code,

ASCE 7-10 "Minimum Design Loads for Buildings and Other Structures",

AISC 360 "Specification for Structural Steel Buildings",

AISC 341 "Seismic Provisions for Structural Steel Buildings"

Site elevation, above mean sea level (ft)	0.60'
Design flood elevation, DFE (ft)	8.00'
Design groundwater elevation (ft)	-1.00'

Wind Design Data:

Ultimate design wind speed, V_{ult} (mph)	200
Nominal design wind speed, V_{asd} (mph)	155
Exposure category	D
Risk Category	III

Snow Design Data:

Ground snow load, P_g (psf)	Zero

Seismic Design Data

Mapped MCE short period spectral response acceleration, S_S	0.021
Mapped MCE one second period spectral response acceleration, S_1	0.013

Risk Category	III
Seismic Design Category	A
Non-Structural Components Seismic Design Category	Exempt from seismic design

3. WIND ANCHORAGE. Equipment that is to be located outdoors shall have anchor bolts designed for the effects of wind forces, as determined in accordance with ASCE 7, Chapters 26-31. Design of anchorage into concrete shall be in accordance with ACI 318 Appendix D, shall consider concrete to be cracked, and shall not include the strengthening effects of supplementary reinforcement or anchor reinforcement unless approved by the Engineer. Post-installed anchors into concrete may be used only when approved by Engineer, and shall be designed in accordance with the anchor manufacturer's research report. Shop drawings shall include full anchor bolt details, and shall be sealed by a professional engineer licensed in the state of the project. Calculations shall be furnished when requested by Engineer.

4. SEISMIC DESIGN.

4-1. General. Structural systems shall provide continuous load paths, with adequate strength and stiffness to transfer all seismic forces from the point of application to the point of final resistance.

4-2. Pre-Engineered Buildings. Pre-engineered buildings shall have sufficient strength and ductility to resist the specified seismic effects defined for buildings and shall meet all of the design, proportioning, detailing, inspection, and quality assurance provisions of the specified building code.

"W" for buildings shall include the total dead load, the total operating weight of permanent equipment and the effective contents of vessels, and applicable portions of other loads, as required by the specified building code.

4-3. Non-Structural Components. Non-structural components such as architectural, mechanical, and electrical items that are permanently attached to and supported by a structure but are not part of the structural system, are exempt from seismic design as indicated in Chapter 11 of ASCE 7.

4-4. Anchorage. Design of anchorage into concrete shall be in accordance with ACI 318 Appendix D, shall consider concrete to be cracked, and shall not include the strengthening effects of supplementary reinforcement or anchor reinforcement unless approved by Engineer. Post-installed anchors into concrete may be used only when approved by Engineer, and shall be designed in accordance with the anchor manufacturer's research report.

Components shall be attached so that forces are transferred to the structural system. All structural attachments shall be bolted, welded, or otherwise positively fastened. Frictional resistance due to gravity shall not be considered in evaluating the required resistance to seismic forces.

4-5. Non-Building Structures. Non-building structures are the items described as such in Chapter 15 of ASCE 7 including the Pumping Station.

Design of non-building structures shall be in accordance with all applicable provisions of ASCE 7, Chapter 15. Liquid containing structures shall also be subject to the provisions of ACI 350 and 350.3 with a low level of seismic risk as outlined in ACI 350, Article 21.2.1.3. "W" shall include the total dead load and shall also include all normal operating contents of tanks and piping.

Non-building structures shall provide sufficient strength and ductility to resist the specified minimum seismic effects, and shall meet all of the design, proportioning, detailing, inspection, and quality assurance provisions of the specified building code and other referenced codes. Non-building structures shall be designed to be operable during and following a design level seismic event, without collapsing, breaking away from supports, creating an ignition hazard, or releasing any contents.

4-6. Submittals. The construction documents shall be submitted in accordance with the Submittal Procedures section.

End of Section

Section 02200

EXCAVATION AND FILL FOR STRUCTURES

PART 1 - GENERAL

1-1. SCOPE. This section covers earthwork and shall include the necessary clearing, grubbing, and preparation of the site; removal and disposal of all debris; excavation; handling, storage, transportation, and disposal of all excavated material; all necessary sheeting, shoring, and protection work; preparation of sub-grades; pumping and dewatering as necessary; protection of adjacent property; backfilling; construction of fills and embankments; grading; and other appurtenant work.

1-2. GENERAL. With reference to the terms and conditions of the construction standards for excavations set forth in OSHA "Safety and Health Regulations for Construction", Chapter XVII of Title 29, CFR, Part 1926, Contractor shall employ a competent person and, when necessary based on the regulations, a licensed or registered professional engineer in the state where the earthwork is located, to act upon all pertinent matters of the work of this section.

1-3. SUBMITTALS. Drawings, specifications, and data covering the proposed materials shall be submitted in accordance with the Submittals Procedures section.

At least 30 days before starting construction on the sheeting and shoring and in accordance with OSHA requirements enumerated above, the Contractor shall ensure that the sheeting and shoring design engineer shall complete and submit to Engineer the Temporary Excavation Design Certificate , Figure 1 – 02200 and the Contractor shall use the sheeting and shoring design. If required by the OSHA requirements enumerated above or to protect existing facilities, then the Contractor is responsible for ensuring that a separate certificate shall be submitted for each unique design. If required for protection of existing facilities or as required by the enumerated OSHA regulations, the certificate shall be signed and sealed by the registered professional engineer that designed the protection system.

1-3.01. Filter Fabric Data. Not used.

1-3.02 Test Results for Preliminary Review of Materials. Complete test results by an independent commercial laboratory retained by the Contractor for preliminary review of materials proposed for use in fills and embankments, structure backfill, select fill, granular fill, gravel beneath slabs, and any other fill material specified herein.

1-3.03 Controlled Low Strength Materials. Not used.

1-4. BASIS FOR PAYMENT.

1-4.01. Sheeting for Excavation of Structures. No additional payment above the Contract Price will be made for steel sheet piling left in place in excavations for structures.

1-5. INSURANCE. Professional Liabilit insurance shall be provided as specified in the Supplementary Conditions.

PART 2 - PRODUCTS

2-1. MATERIALS.

2-1.01. Filter Fabric. Not used.

2-1.02. Polyethylene Film. Polyethylene film beneath concrete slabs or slab base course material shall be Product Standard PS17, 6 mil minimum thickness.

2-1.03. General Fill and Backfill Materials. To the maximum extent available, excess suitable material obtained from structure shall be used for the construction of general fills and backfills. Additional material shall be provided from Contractor's off-site source. No borrow pits shall be opened on site unless such pits are specifically indicated on the Drawings.

All material placed in fills and backfills shall be free from rocks or stones larger than the required size in their greatest dimension, brush, stumps, logs, roots, debris, and other organic or deleterious materials. The maximum size of stone in fills and backfill shall be 1 inch. No rocks or stones shall be placed in the upper 24 inches of any fill or backfills. Rocks or stones within the allowable size limit may be incorporated in the remainder of fills and backfills, provided they are distributed so that they do not interfere with proper compaction.

2-1.04. Granular Fill. Granular fill material shall be crushed rock or gravel suitable for use as a free draining sub-base beneath slabs and foundations. Granular fill shall be free from dust, clay, and trash; hard, durable, non-friable; and shall be graded 3/4 inch to No. 4 as defined in ASTM C33 for No. 67 coarse aggregate. Granular fill shall meet the quality requirements for ASTM C33 coarse aggregate. Only crushed rock with angular particles shall be used when the perimeter of the granular fill is not confined or otherwise subject to raveling, such as on a slope.

2-1.05. Structure Backfill. Structure backfill shall be defined as the material placed around and outside of structures. For structures constructed in open excavations, structure backfill shall extend to the temporary excavation slope so that the entire excavation outside the structure shall be filled with structure

backfill. For structures constructed in supported excavations, the structure backfill shall completely fill the space between structure and excavation support system, or between structure and excavation face, if these specifications permit removal of the excavation support system. Structure backfill shall be as indicated herein.

2-1.05.01. General Fill Structure Backfill. General fill for structure backfill shall meet the requirements of the previous paragraph entitled "General Fill and Backfill Materials" with additional requirement that the fill shall be classified as GW, GP, GM, GC, SW, SP, SM, SC, SW-SM, SW-SC, SP-SM, SP-SC in accordance with ASTM D2487.

2-1.05.02. Crushed Rock Structure Backfill. Crushed rock for structure backfill shall meet the following gradation requirements:

Size	Percent Passing
1/2 inch	100
3/8 inch	90 – 100
No. 4	30 – 60
No. 8	0 – 10
No. 200	0 - 5

2-1.05.03. Clean Sand Structure Backfill. Not used.

2-1.06. Select Fill. Select fill shall be defined as the material placed beneath the structure foundations and slabs below any granular material layer or lean concrete slab indicated on the Drawings. Select fill shall be used to replace any unsuitable material below the structure foundations and slabs and to raise the site grades below and within 5 feet (unless a larger dimension is otherwise indicated on the Drawings or specified) of structural footprints and at locations indicated on the Drawings. Select fill shall be as indicated herein.

2-1.06.01. General Fill Select Fill. General fill for use as select fill shall meet the requirements of the previous paragraph entitled “General Fill and Backfill Materials” with additional requirement that the fill shall be classified as GW, GP, GM, GC, SW, SP, SW-SM, SW-SC, SP-SM, SP-SC in accordance with ASTM D2487 with less than 12 percent passing the No. 200 Sieve and should not contain more than 5 % by weight of organic matter.

2-1.06.02. Crushed Rock Select Fill. Crushed rock for select fill shall meet the following gradation requirements:

Size	Percent Passing
1/2 inch	100
3/8 inch	90 – 100
No. 4	30 - 60
No. 8	0 - 10
No. 200	0 - 5

2-1.06.03. Clean Sand Select Fill. Not used.

2-1.07. Gravel Base Beneath Slabs. "Gravel Base Beneath Slabs" is defined as material to be placed directly beneath floor slabs of building as shown on the Drawings. The material shall meet the quality requirements specified for ASTM C33 concrete coarse aggregate and shall be graded No. 7 coarse aggregate.

2-1.08. Controlled Low Strength Material (CLSM). Not used.

2-1.09. Geocomposite Sheet Drains. Not used.

2-2. MATERIAL TESTING.

2-2.01. Preliminary Review of Materials. As stipulated in the Quality Control section, all tests required for preliminary review of materials shall be made by an acceptable independent testing laboratory at the expense of Contractor. Tests performed by the aggregate supplier are not acceptable. Tests for preliminary review of materials shall have been performed within 2 months of submittal and shall be representative of the material that will be delivered to the Site. Acquisition of samples for testing shall be by the Contractor's independent testing laboratory. Aggregate materials shall be sampled in accordance with ASTM D75. Two initial gradation tests shall be made for each type of general fill, select fill, structure backfill, granular fill, or other specified material, and one additional gradation test shall be made for each additional 500 tons of each material delivered (imported) to the jobsite or suitable onsite material incorporated in select fill or structure backfill. One additional gradation test shall be performed for each additional 2,000 tons of general fill material delivered to the jobsite or suitable onsite material incorporated in general fill. In addition, one set of initial Atterberg Limits test shall be made for each fill material containing more than 20 percent by weight pass the No. 200 sieve and for materials specified by Atterberg Limits. One additional Atterberg Limits test shall be made for each additional 500 tons of each material delivered to the job site or otherwise incorporated in select fill or structure backfill. One additional Atterberg Limits test shall be made for each additional 2,000 tons of general fill material delivered to the jobsite or suitable onsite material incorporated in general fill.

2-2.02. Field Testing Expense. All moisture-density (Proctor) tests and relative density tests on the materials, and all in-place field density tests, shall be made by an independent testing laboratory at the expense of Contractor. Contractor shall provide access to the materials and work area and shall assist the laboratory as needed in obtaining representative samples.

2-2.03. Required Field Tests. For planning purposes, the following guidelines shall be used for frequency of field tests. Additional tests shall be performed as necessary for job conditions and number of failed tests. Test results shall be submitted as indicated in the Submittals Procedures section.

Two moisture-density (Proctor) tests in accordance with ASTM D698 (or, when required, ASTM D1557), or two relative density tests in accordance with ASTM D4253 and D4254 for each type of general fill, select fill, structure backfill, granular fill, or other material proposed.

For area fills and backfills, an in-place field density and moisture test for each 1000 cubic yards of material placed.

Minimum one in-place field density and moisture test for every 100 to 200 cubic yards or every lift of structure backfill or select fill whichever yields the greatest amount of test.

Minimum one in-place density and moisture test whenever there is a suspicion of a change in the quality of moisture control or effectiveness of compaction.

At least one test for every full shift of compaction operations on mass earthwork.

Additional gradation, proctor, and relative density tests whenever the source or quality of materials changes.

PART 3 - EXECUTION

3-1. SITE PREPARATION. All sites to be occupied by permanent construction shall be cleared of all logs, trees, roots, brush, tree trimmings, and other objectionable materials and debris. All stumps shall be grubbed. Subgrades for fills and backfills and sites to be occupied by permanent construction shall be cleaned and stripped of all surface vegetation, sod, and organic topsoil. All waste materials shall be removed from the site and disposed of by and at the expense of Contractor.

3-2. EXCAVATION.

3-2.01. General. Excavations shall provide adequate working space and clearances for the work to be performed therein and for installation and removal of concrete forms. In no case shall excavation faces be undercut for extended footings.

Subgrade surfaces shall be clean and free of loose material of any kind when concrete is placed thereon.

3-2.02. Temporary Excavations. Except where excavation side slopes are cut to a stable slope, excavations for structures and trenches shall be supported as necessary to prevent caving or sliding. Temporary earth retention systems shall be furnished and installed as necessary to limit the extent of excavations for the deeper structures and necessary backfill under adjacent shallower structures, and to protect adjacent structures and facilities from damage due to excavation and subsequent construction.

Design of excavations by a professional engineer retained by Contractor is required when necessary to protect adjacent existing facilities, or when design by an engineer is required by the OSHA regulations cited herein. The Contractor's professional engineer shall be licensed in the state of the Project and is responsible for design of entire excavation (both the sloping and supported portions of the excavation). The design of temporary earth retention shall comply with the paragraph of this specification titled, "Temporary Earth Retention."

Before starting construction on a temporary excavation requiring design by a professional engineer in compliance with requirements of this specification (to protect existing structures, utilities, and other facilities), the Contractor shall ensure that the temporary excavation design engineer shall complete the Temporary Excavation Design Certificate (Figure 1 – 02200) and the Contractor shall submit the certificate along with proof of professional liability insurance for the temporary excavation designer. The Contractor shall use the temporary excavation design. The Contractor shall submit a separate certificate for each unique design.

3-2.03. Classification of Excavated Materials. No classification of excavated materials will be made for payment purposes. Excavation and trenching work shall include the removal and subsequent handling of all materials excavated or otherwise removed in performance of the work, regardless of the type, character, composition, or condition thereof.

3-2.04. Preservation of Trees. No trees shall be removed outside excavated or filled areas, unless their removal is authorized by Owner. Trees left standing shall be adequately protected from damage by construction operations.

3-2.05. Unauthorized Excavation. Except where otherwise authorized, indicated, or specified, all materials excavated below the bottom of concrete walls, footings, slabs on grade, and foundations shall be replaced with concrete or lean concrete at the expense of Contractor. If structural concrete replacement is chosen, it shall be with concrete placed at the same time and monolithic with the concrete foundation.

3-2.06. Blasting. Blasting or other use of explosives for excavation will not be permitted.

3-2.07. Dewatering. Dewatering equipment shall be provided to remove and dispose of all surface water and groundwater and all water, regardless of the source, entering excavations, trenches, or other parts of the work. Each excavation shall be kept dry during subgrade preparation and continually thereafter until the structure to be built, or the pipe to be installed therein, is completed to the extent that no damage from hydrostatic pressure, flotation, or other cause will result.

All excavations for concrete structures which extend down to or below groundwater shall be dewatered by lowering and keeping the groundwater level to the minimum depth of 12 inches , beneath such excavations. The specified dewatering depth shall be maintained below the prevailing bottom of excavation at all times.

Surface water shall be diverted or otherwise prevented from entering excavations or trenches to the greatest extent possible without causing damage to adjacent property.

Contractor shall be responsible for the condition of any pipe or conduit used for drainage purposes, and all such pipe or conduit shall be left clean and free of sediment.

3-2.08. Sheeting and Shoring. Except where banks are cut back on a stable slope, excavations for structures shall be supported as necessary to prevent caving or sliding.

Steel sheet piling or other excavation support systems shall be furnished and installed as necessary to limit the extent of excavations for the deeper structures and necessary backfill under adjacent shallower structures, and to protect adjacent structures and facilities from damage due to excavation and subsequent construction. Contractor shall assume complete responsibility for and install adequate protection systems for prevention of damage to existing facilities.

Excavation support systems and sheeting and shoring shall be all removed after completion of work.

Unless the excavation support is required to be left in place the design of the excavation support system shall be such as to permit complete removal while maintaining safety and stability in the excavation at all times. Excavation support systems to be left in place shall be designed and constructed of only steel and pressure treated timber elements. Excavation support elements are left in place shall be cut off a minimum of 24 inches below finish grade. No additional

payment above the Contract Price will be made for excavation support components left in place. Untreated timber shall not be used.

Sheeting, shoring and excavation support systems shall be designed by a professional engineer registered in the state where the project is located.

3-2.09. Foundation Subgrade Preparation. Sub-grades for concrete structures shall be firm, dense, and thoroughly compacted and consolidated; shall be free from mud and muck; and shall be sufficiently stable to remain firm and intact under the feet of the workers.

Sub-grades for concrete structures which are otherwise solid, but which become mucky on top due to construction operations, shall be reinforced with crushed rock or gravel as specified for granular fills. The stabilizing material shall be placed in such a manner that no voids remain in the granular fill. All excess granular fill with unfilled void space shall be removed. The finished elevation of stabilized sub-grades shall not be above sub-grade elevations indicated on the Drawings.

3-2.10. Ring-wall Excavation. Not used.

3-2.11. Roadway Excavation. Excavation for the roadways, drives, and parking areas shall conform to the lines, grades, cross sections, and dimensions indicated on the Drawings and shall include the excavation of all unsuitable material from the subgrade. After shaping to line, grade, and cross section, the subgrade shall be compacted to a depth of at least 6 inches and shall meet the following:

Test method to determine maximum density and moisture.	ASTM D1557.
Relative compaction and moisture content relative to the optimum.	98%
Moisture content relative to the optimum.	-2% to +2%.

This operation shall include any reshaping and wetting or drying required to obtain proper compaction. All soft or otherwise unsuitable material shall be removed and replaced with suitable material.

3-3. FILLS AND BACKFILLS. Fills and backfills not required or indicated to be designated fills shall be constructed as general fills and backfills. All fills and embankments shall be constructed to the lines and grades indicated on the Drawings. Construction of fills and backfills shall begin from the lowest elevation in a given excavation or area and progress upward. Materials shall be deposited in approximately horizontal layers not to exceed 8 inches in uncompacted

thickness. Unless otherwise specified herein, the following governing standards apply:

Test method to determine maximum density and moisture.	ASTM D1557.
Relative compaction.	98 %.
Moisture content relative to the optimum.	-2% to +2%.

3-3.01. Sub-grade Preparation. After preparation of the fill or embankment site, the sub-grade shall be scarified and moisture conditioned to a minimum depth of 6 inches , leveled and rolled so that surface materials of the sub-grade will be at a moisture content and as compact and well bonded with the first layer of the fill or embankment as specified for subsequent layers.

Unless otherwise directed by Engineer, the sub-grade shall be proof-rolled by a rubber-tired roller, a loaded dump truck, or other suitable rubber-tired equipment acceptable to Engineer. A minimum of four passes of the proof-rolling equipment shall be provided such that the last two passes are made perpendicular to the first two passes.

All soft, yielding, or otherwise unsuitable material shall be removed and replaced with compacted fill.

3-3.02. Placement and Compaction. All fill and backfill materials shall be placed in approximately horizontal layers not to exceed 8 inches in un-compacted thickness. Material deposited in piles or windrows by excavating and hauling equipment shall be spread and leveled before compaction.

Each layer of material shall have the best practicable moisture content for satisfactory compaction. The material in each layer shall be wetted or dried to achieve the moisture content relative to optimum as specified above and shall be thoroughly mixed to ensure uniform moisture content and adequate compaction. Each layer shall be thoroughly compacted to the required degree of compaction at the required moisture content. If the material fails to meet the density specified, compaction methods shall be altered. The changes in compaction methods shall include, but not be limited to, changes in compaction equipment, reduction in uncompacted lift thickness, increase in number of passes, and better moisture control.

Wherever a pipe is to be installed within a fill or backfill, the fill or backfill materials shall be placed and compacted to an elevation not less than 12 inches above the top of pipe elevation before the trench for pipe installation is excavated.

3-3.03. Borrow Pits. Borrow pits are not permitted.

3.4 FILL AND BACKFILL FOR STRUCTURES. Earth and aggregate materials placed for structures include granular fill, structure backfill, select fill, gravel base beneath slabs, and controlled low strength material. In addition to the specific requirements specified herein, all requirements for placement of fills and embankments shall apply to granular fill, structure backfill, select fill, and gravel base beneath slabs. These requirements include, but are not limited to subgrade preparation, lift thickness, and moisture conditioning requirements. All fills and backfills for structures shall be constructed to the lines and grades indicated on the Drawings. Backfilling and construction of fills during freezing weather shall not be done. No backfill, fill, or embankment materials shall be installed on frozen surfaces, nor shall frozen materials, snow, or ice be placed in any backfill, fill, or embankment.

3-4.01. Granular Fill. Granular fills shall be provided where indicated on the Drawings. Granular fills shall be placed on suitably prepared sub-grades in uncompacted lift thickness of 6 inches or less and compacted by vibration. Granular fills shall be compacted to not less than 70 percent relative density as determined by ASTM D4253 and D4254. If the thickness of the granular fill is less than 6 inches, the compaction shall be by a minimum four passes (round trips) of a self-propelled or walk-behind type vibratory roller operating in full vibration mode in accordance with manufacturer's instructions.

Where granular fills are to be covered with concrete, the top surface shall be graded to the required sub-grade elevation. The completed fill shall be covered by polyethylene film.

3-4.02. Structure Backfill. Backfill materials shall be deposited in approximately horizontal layers not to exceed 8 inches in uncompacted thickness and shall meet the following requirements:

Test method to determine maximum density and moisture.	ASTM D1557.
Relative compaction.	98%.
Moisture content relative to the optimum.	-2% to +2%.

Compaction of structure backfill shall be performed in such a manner that damage to the structure is prevented. The compaction equipment used within 8 feet of the walls and for the top 8 feet of backfill shall have no restriction on type. Limit of equipment weight shall be 1 ton. 2 ton. Compaction of structure backfill by inundation with water will not be permitted.

No backfill shall be deposited or compacted in water.

Care shall be taken to compact structure backfill which will be beneath pipes, drives, roads, parking areas, walks, curbs, gutters, or other surface construction or structures. In addition, wherever a pipe is to be installed within structure backfill, the structure backfill shall be placed and compacted to an elevation not less than 12 inches above the top of pipe before the trench for pipe installation is excavated. Compacted areas, in each case, shall be adequate to support the item to be constructed or placed thereon.

3-4.03 Select Fill. Select fill shall be placed in approximately horizontal layers in uncompacted lift thickness of 8 inches or less and shall meet the following requirements:

Test method to determine maximum density and moisture.	ASTM D1557.
Relative compaction.	98%.
Moisture content relative to the optimum.	-2% to +2%.

3-4.04. Gravel Base Beneath Slabs. The gravel base beneath building floor slabs shall be placed in uncompacted lift thickness of 6 inches or less and compacted with a minimum of four passes (round trips) of a self-propelled or walk-behind type vibrating roller. The roller shall be operated in the full vibrating mode and in accordance with the manufacturer's instructions.

3-4.05. Controlled Low Strength Material (CLSM) Fill. Not used.

3-4.06. Ringwall Fill. Not used.

3-5. FILTER FABRIC INSTALLATION. Not used.

3-6. GEOCOMPOSITE SHEET DRAINS INSTALLATION. Not used.

3-7. FINAL GRADING AND PLACEMENT OF TOPSOIL. After other outside work has been finished, and backfilling and constructions completed and settled, all areas which are to be graded shall be brought to grade at the indicated elevations, slopes, and contours. All cuts, fills, backfills, and other areas which have been disturbed or damaged by construction operations shall be surfaced with topsoil to a depth of at least 4 inches . Topsoil shall be of a quality at least equal to the existing topsoil in adjacent areas, free from trash, stones, and debris, and well suited to support plant growth. Any additional topsoil required to provide the required minimum thickness shall be at no additional cost to the Owner.

Use of graders or other power equipment will be permitted for final grading and dressing of slopes, provided the result is uniform and equivalent to manual

methods. All surfaces shall be graded to secure effective drainage. Unless otherwise indicated, a slope of at least 1 percent shall be provided.

Final grades and surfaces shall be smooth, even, and free from clods and stones, weeds, brush, and other debris.

3-8. DISPOSAL OF EXCAVATED MATERIALS. Suitable excavated materials may be used in fills and backfills as needed. All excess excavated material shall be disposed of off site at the expense of Contractor.

All debris, stones, logs, stumps, roots, and other unsuitable materials shall be removed from the site and disposed of by, and at the expense of, Contractor.

3-9. RESODDING. All established lawn areas cut by excavation, or damaged during the work shall be resodded, after completion of construction, to the complete satisfaction of the property owner and Owner. All sod used shall be the same type as removed or damaged, shall be best quality, and, when placed, shall be live fresh growing grass with at least 1-1/2 inches of soil adhering to the roots.

All sod shall be procured from areas where soil is fertile and contains a high percentage of loamy topsoil and from areas that have been grazed or mowed sufficiently to form a dense turf.

Sod shall be transplanted within 24 hours from the time it is harvested, unless stacked at its destination in a suitable manner. All sod in stacks shall be kept moist and protected from exposure to the sun. In no event shall more than 1 week elapse between cutting and planting.

Before placing sod, all shaping and dressing of the areas shall have been completed. After shaping and dressing, commercial fertilizer of a type acceptable to Owner shall be applied uniformly in the manner and amounts recommended by the manufacturer and harrowed lightly. Sodding shall follow immediately.

3-10. SETTLEMENT. Contractor shall be responsible for all settlement of fills and backfills which may occur within the correction period stipulated in the General Conditions.

Contractor shall make, or cause to be made, all repairs or replacements made necessary by settlement within 30 days after notice from Engineer or Owner.

End of Section

Section 03301

CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1-1. SCOPE. This section covers all cast-in-place concrete, including reinforcing steel, forms, finishing, curing, and appurtenant work.

Both inch-pound (English) and SI (metric) units of measurement are specified herein; the values expressed in inch-pound units shall govern.

1-2. GENERAL. All cast-in-place concrete shall be accurately formed and properly placed and finished as indicated on the drawings and as specified herein.

1-2.01. Concrete Classifications. Concrete classifications shall be defined and used as indicated for the following classes:

Concrete Classifications

Class	Class Description
A	Foundation Slabs and Footings Concrete for footings, foundations, manholes, catch basins, pan-formed joists, and all other structural concrete other than for liquid-containing structures.
B	Exterior Flatwork Concrete. Concrete for exterior slabs on grade, plant pavement, sidewalks, curbs and gutters, and small equipment pads.
C	Ductbanks, Pipe Blocking, Concrete Fill, and Pipe Encasement Concrete. Concrete used in ductbanks, pipe blocking, concrete fill and pipe encasements.
D	Lean Concrete. Used as a fill material for over-excavations or for mud slabs below foundations. Controlled Low-Strength Material (CLSM) used as an easily removable fill material is covered in the Excavation and Fill for Structures section.

1-3. SUBMITTALS. All submittals of drawings and data shall be in accordance with the Submittals Procedures section.

The following items shall be submitted for review:

Aggregate reports (ASTM C33)	
	Source and type
	Gradation
	Deleterious materials
	Alkali-aggregate reactivity
Cement mill report	
Fly ash or slag cement test report	
Admixture data sheets	
Proposed mixture proportions	
Concrete compressive strength at 28 days	
NSF 61 compliance evaluation	

1-4. STORAGE AND HANDLING. Cement shall be stored in suitable moistureproof enclosures. Cement which has become caked or lumpy shall not be used.

Aggregates shall be stored so that segregation and the inclusion of foreign materials are prevented. The bottom 6 inches [150 mm] of aggregate piles in contact with the ground shall not be used.

Reinforcing steel shall be carefully handled and shall be stored on supports that will prevent the steel from touching the ground.

PART 2 - PRODUCTS

2-1. LIMITING REQUIREMENTS. Unless otherwise specified, concrete shall be controlled within the limiting requirements listed in Table 1.

2-1.01. Cement Content. The minimum quantity of Portland cement in the concrete shall be as indicated in Table 1.

The cementitious material content shall not be increased beyond the Table 1 values more than necessary to achieve the required f'_{cr}.

2-1.02. Maximum Water-Cementitious Ratio. The maximum water-cementitious material ratio shall be on a cement mass basis, or, if fly ash or slag cement is used, the combined mass of cement plus fly ash or slag cement shall be used to determine the water-cementitious materials ratio. Limiting maximum water-cementitious material ratios are indicated in Table 1

2-1.03. Fly Ash and Slag Cement Content. At the option of Contractor, fly ash or slag cement may be substituted for portland cement, on the basis of 1.0 lb added for each 1.0 lb of cement reduction. Fly ash replacement shall be within a range of 15 to 25 percent. Slag cement replacement shall be within a range of 25 to 50 percent. Mixtures using slag cement in combination with fly ash will not be acceptable.

2-1.04. Coarse Aggregate. The maximum nominal coarse aggregate size shall be 1 inch [25 mm].

2-1.05. Slump. Concrete slump shall be kept as low as possible, consistent with proper handling and thorough consolidation. Prior to the addition of admixtures, slump shall be at least 2 inches [50 mm] and shall not exceed the maximum slump as indicated in Table 1.

When superplasticizer is dispensed at the ready-mix plant, the concrete mixture design shall be based on a maximum slump as indicated in Table 1. When superplasticizer is dispensed at the Site, the slump of the concrete delivered shall not exceed the maximum slump as indicated in Table 1 before superplasticizer is added.

2-1.06. Total Air Content. The total volumetric air content of concrete after placement shall be as indicated in Table 1, and within ±1.5 percent. Air-entraining admixture may be omitted from concrete for interior slabs which are to be steel trowel finished.

2-1.07. Admixtures. The admixture content, batching method, and time of introduction to the mix shall be in accordance with the manufacturer's recommendations and acceptable to Engineer. A water-reducing admixture and an air-entraining admixture shall be included in all concrete. A midrange water reducer or a high-range water reducer (superplasticizer) may be used at Contractor’s option. No calcium chloride or admixture containing chloride from sources other than impurities in admixture ingredients will be acceptable.

2-1.08. Strength. The minimum acceptable compressive strengths, as determined by ASTM C39, shall be as indicated in Table 1.

Cylinders shall be 6 inches [150 mm] diameter by 12 inches [300 mm] high for concrete mixes using a maximum nominal aggregate size of 1 inch [25 mm] or larger. Cylinders may be either 6 inches [150 mm] diameter by 12 inches [300 mm] high, or 4 inches [100 mm] diameter by 8 inches [200 mm] high for concrete mixes using a maximum nominal aggregate size of less than 1 inch [25 mm]. The average compressive strength shall be determined from the results of at least three cylinders when using 4 inch [100 mm] diameter cylinders, and at least

two cylinders when using 6 inch [150 mm] diameter cylinders. All tests shall be performed using the same sized cylinders for the duration of the work.

2-2. MATERIALS.

Cement	ASTM C150, Type II or I/II, low alkali .
Fly Ash	ASTM C618, Class F, except loss on ignition shall not exceed 4 percent.
Slag Cement	ASTM C989, Grade 100 or Grade 120.
Fine Aggregate	Non-reactive, clean natural sand, ASTM C33. Artificial or manufactured sand will not be acceptable.
Coarse Aggregate	Non-reactive crushed rock, washed gravel, or other inert granular material conforming to ASTM C33, class 4S, except that clay and shale particles shall not exceed 1 percent.
Water	Potable. Water from concrete production operations shall not be used.
Admixtures	
Water-Reducing	ASTM C494, Type A or D.
Air-Entraining	ASTM C260.
Superplasticizing	ASTM C494, Type F or G.
Reinforcing Steel	
Bars	ASTM A615, Grade 60, deformed.
Welded Wire Fabric	ASTM A185 or A497.
Bar Supports	CRSI Class 1, plastic protected; or Class 2, stainless steel protected.

Mechanical Connectors	Splicing system meeting Type 2 tensile requirements of ACI 318. Products shall have a current evaluation report verifying testing per ICC-ES AC 133. Use only where indicated on the drawings.
Metal Waterstops	Uncoated carbon steel, 12 gage minimum thickness, size as indicated on the drawings.
PVC Waterstops	Extruded, virgin, elastomeric, polyvinyl chloride (PVC), white (no pigment), ribbed, 3/8 inch [9.5 mm] thick. Reclaimed material will not be acceptable. Provide hog rings or grommets spaced at 12 inches [300 mm] on center entire length.
At construction joints in concrete sections less than 12 inches [300 mm] in thickness	6 inches [150 mm] wide; Greenstreak “679” or Vinylex “R638”.
At construction joints in concrete sections 12 inches [300 mm] or more in thickness	9 inches [225 mm] wide; Greenstreak “646” or Vinylex “R938”.
Expandable Waterstops, permitted only at locations indicated on Drawings	
For concrete sections that are at least 10 inches [300 mm] thick and 6 feet [1.8 m] high, and with at least two layers of reinforcement	Hydrophilic; bentonite free, chemically modified rubber. Adeka "Ultra Seal MC-2010MN" or Greenstreak "Hydrotite CJ-1020-2K". Adhesive and sealant as recommended by the manufacturer.
For other concrete sections	Hydrophilic; chemically modified rubber. Adeka "KBA-1510FP" or Greenstreak "Swellstop". Adhesive and sealant as recommended by the manufacturer.
Forms	
Plywood Product	Standard PS1, waterproof, resin-bonded, exterior type, Douglas fir.

Lumber	Straight, uniform width and thickness, and free from knots, offsets, holes, dents, and other surface defects.
Form Coating	Nonstaining and nontoxic after 30 days. Product shall not exceed VOC limits established by the federal, state, or local regulatory agency having jurisdiction over the project site.
Evaporation Reducer	Dayton Superior "AquaFilm Concentrate J74", Euclid "Eucbar", L&M Chemical "E-Con", BASF "MasterKure ER50", or Sika "SikaFilm".
Polyethylene Film	Product Standard PS17 or ASTM D4397, 6 mils [150 µm] or thicker.
Vapor retarder and seam tape	Polyolefin membrane, 15 mil [0.38 mm] min, ASTM E1745, Class A, with maximum water vapor permeance of 0.02 perms. Stego Industries “Stego Wrap 15 Mil”, Raven Industries “Vaporblock 15”, Reef Industries “Griffolyn 15 Mil Green”, W.R. Meadows “Perminator 15”, Insulation Solutions “Viper VaporCheck II”. Manufacturer recommended seam tape and pipe boots.
Membrane Curing Compound and Floor Sealer	ASTM C1315, Type I, Class A, minimum 25 percent solids, acrylic, non-yellowing, unit moisture loss 0.40 kg/m^2 maximum in 72 hours. Product shall not exceed VOC limits established by the federal, state, or local regulatory agency having jurisdiction over the project site.
Concrete Surface Coloring/Hardener	Mineral aggregate dry-shake colored hardener for concrete flatwork. ChemSystems, Inc. “CSI Heavy-Duty Color Hardener”, Euclid “Surflex”, or Dayton Superior “Quartz Tuff”.
Epoxy Bonding Agent	ASTM C881, Type V, moisture insensitive, 100 percent solids; Dayton Superior “Sure Bond J58”, Euclid "Euco #452", or Prime Resins “Prime Bond 3000”.

2-3. MIXTURE DESIGN AND TESTING. All reports and tests required for Engineer acceptance of materials and concrete mixtures shall be made at the expense of Contractor. Mixtures shall be adjusted in the field as necessary, within the limits specified, to meet the requirements of these specifications. If the source of any concrete materials is changed during the contract, concrete work shall pause until the new materials and the new mixture design are acceptable to Engineer.

2-3.01. Review of Materials. The source and quality of concrete materials shall be submitted to Engineer for review before concrete is placed.

2-3.02. Proposed Mixture Proportions. Proposed proportions of concrete shall meet the limiting requirements indicated herein.

2-3.03. Mixture Testing. Test results shall be submitted for review and shall be acceptable to Engineer before concrete work is started.

2-3.03.01. Field Test Record Data. Concrete mixtures may be qualified based on field test record performance data. Field test data records shall be from the production facility being used on the current Project and shall have been performed in the past 12 months. Field test records shall represent a single group of at least 10 consecutive strength tests for one mixture, using the same materials, under the same conditions, and encompassing a period of not less than 45 days.

2-3.03.02. Laboratory Trial Mixture Testing. If field test record data is not available, or does not meet the specified criteria, laboratory trial mixtures shall be performed to confirm concrete strength requirements. Laboratory trial mixtures shall meet a minimum compressive strength of f'_c + 1200 psi.

2-4. FORMS. Forms shall be designed to produce hardened concrete having the shape, lines, and dimensions indicated on the drawings. Forms shall be substantial and sufficiently tight to prevent leakage of mortar and shall be maintained in proper position and accurate alignment.

Forms for pavement, curbs, or gutters shall be made of steel and shall be supported on thoroughly compacted earth. The top face of pavement forms shall not vary from a true plane more than 1/4 inch in 10 feet [2 mm/m].

Forms shall be thoroughly cleaned and coated before concrete is placed.

Form-facing materials shall be selected in accordance with ACI 347.3R, based upon the applicable formed concrete surface category. Formed concrete surface

categories vary by structure and application, and shall be as indicated in the Finishing Formed Surfaces paragraph.

2-4.01. Form Ties. Form ties shall be of the removable end, permanently embedded body type, and shall have sufficient strength and rigidity to support and maintain the form in proper position and alignment without the use of auxiliary spreaders. Form ties for liquid-containing walls shall be provided with waterstop washers located on the permanently embedded portions of the ties at the approximate center of the wall. Through-wall tapered removable ties will not be acceptable for liquid-containing walls.

2-4.02. Edges and Corners. Chamfer strips shall be placed in forms to bevel all salient edges and corners, except the top edges of walls and slabs which are to be tooled and edges which are to be buried. Unless otherwise noted, bevels shall be 3/4 inch [19 mm] wide.

2-4.03. Form Removal. Forms shall not be removed or disturbed until the concrete has attained sufficient strength to safely support all dead, live, and construction loads. Care shall be taken in form removal to avoid surface gouging, corner or edge breakage, and other damage to the concrete.

2-5. REINFORCEMENT. Reinforcement shall be accurately formed and positioned and shall be maintained in proper position while the concrete is being placed and compacted. Unless otherwise indicated on the drawings, the details of fabrication shall conform to ACI 315 and 318. In case of conflict, ACI 318 shall govern. Reinforcement shall be free from dirt, loose rust, scale, and contaminants. Mechanical connections shall be used only as indicated on the drawings.

PART 3 - EXECUTION

3-1. BATCHING, MIXING, AND DELIVERY. Concrete shall be furnished by an acceptable ready-mixed concrete supplier, and shall conform to ASTM C94 except as indicated otherwise in this specification.

3-1.01. Delivery Tickets. A delivery ticket shall be prepared for each load of ready-mixed concrete and a copy of the ticket shall be handed to Engineer by the truck operator at the time of delivery. Tickets shall indicate the name and location of Contractor, the project name, the mixture identification, the quantity of concrete delivered, the quantity of each material in the batch, the outdoor temperature in the shade, the time at which the cementitious materials were added, and the numerical sequence of the delivery.

3-1.02. Mixing Water. Mixing water shall not be added in transit. Any amount of water withheld from the truck mixer shall be clearly indicated on the delivery

ticket. Water added at the site shall not exceed the amount withheld, and shall not be added without oversight by Owner's on site inspector.

3-1.03. Consistency. The consistency of concrete shall be suitable for the placement conditions. Aggregates shall flow uniformly throughout the mass, and the concrete shall flow sluggishly when vibrated or spaded. The slump shall be kept uniform.

3-2. PLACEMENT. Contractor shall inform Engineer at least 24 hours in advance of the times and places at which he intends to place concrete.

Methods of conveying concrete to the point of final deposit and of placing shall prevent segregation or loss of ingredients. During and immediately after placement, concrete shall be thoroughly compacted and worked around all reinforcement and embedments and into the corners of the forms. Concrete shall be compacted by immersion-type vibrators, vibrating screeds, or other suitable mechanical compaction equipment. The use of "jitterbug" tampers to compact concrete flatwork will not be permitted.

3-2.01. Polyethylene Film. Where concrete is placed against gravel or crushed rock which does not contain at least 25 percent material passing a No. 4 [4.75 mm] sieve, such surfaces shall be covered with polyethylene film. Joints in the film shall be lapped at least 6 inches [150 mm] and taped.

3-2.02. Vapor Retarder. Vapor retarder shall be installed at the locations indicated on the Drawings. Installation shall be in accordance with ASTM E1643 and the manufacturer's recommendations. Joints in the retarder shall be sealed with waterproof sealing tape. Care shall be exercised to avoid tearing or puncturing the retarder. Any damage shall be promptly repaired, and the retarder shall be inspected for damage immediately before the concrete is placed.

3-2.03. Cold Weather Concreting. Except as modified herein, cold weather concreting shall comply with ACI 306.1.

When placed, heated concrete shall not be warmer than 80°F [26°C].

3-2.04. Hot Weather Concreting. Except as modified herein, hot weather concreting shall comply with ACI 305.1.

At air temperatures of 90°F [32°C] or above, concrete shall be kept as cool as practicable during placement. The temperature of the concrete when placed in the work shall not exceed 90°F [32°C].

Plastic shrinkage cracking due to rapid evaporation of moisture shall be prevented. Concrete shall not be placed when the evaporation rate (actual or anticipated) equals or exceeds 0.2 lb per square foot per hour [1 kg/m^2/h], as determined using the nomograph in Appendix A of ACI 305.1.

3-3. WATERSTOPS. Each waterstop shall be continuous throughout the length of the joint in which it is installed. Waterstops shall be clean, free from coatings, and shall be maintained in proper position until surrounding concrete has been deposited and compacted.

Junctions between adjacent sections of metal waterstops shall be lapped 5 inches [130 mm] and securely bolted, screwed, or spot welded together.

Junctions between adjacent sections of elastomeric (PVC) waterstops shall be spliced in strict conformity with the recommendations of the manufacturer. Directional changes and intersections shall be factory fabricated by the waterstop manufacturer prior to delivery to the site of the work. Field splices will be acceptable only in straight sections.

3-4. FINISHING.

3-4.01. Finishing Formed Surfaces. Formed concrete surfaces shall meet all criteria of the relevant formed concrete surface category (CSC), as defined in ACI 347.3R, except as indicated otherwise herein. Surfaces shall be assigned to CSC's as indicated.

Formed Concrete Surface Category	Applicable Surfaces	Mockup Required
CSC1	Formed concrete surfaces that will be in permanent contact with earth backfill.	No
CSC2	All other formed concrete surfaces not designated otherwise.	No
CSC3	None.	Yes
CSC4	None.	Yes

3-4.01.01. Tie Holes. All tie holes in formed surfaces, regardless of the relevant CSC, shall be cleaned, wetted, and filled with patching mortar. The patches shall be finished flush and cured and shall match the texture and color of the adjacent concrete.

3-4.01.02. Mockups. Not used.

3-4.02. Finishing Unformed Surfaces. Unless otherwise specified, unformed surfaces shall be screeded and given an initial float finish as soon as the concrete has stiffened sufficiently for proper working. Any piece of coarse aggregate which is disturbed by the float or which causes a surface irregularity shall be removed and replaced with mortar. Initial floating shall produce a surface of uniform texture and appearance, with no unnecessary working of the surface.

Initial floating shall be followed by a second floating at the time of initial set. The second floating shall produce a finish of uniform texture and color and the completed finish for unformed surfaces unless indicated otherwise.

3-4.03. Troweling. Interior floor surfaces which will be exposed after construction is completed; exposed top surfaces of equipment bases and interior curbs; and other surfaces designated on the drawings shall be steel trowel finished. Troweling shall be performed after the second floating when the surface has hardened sufficiently to prevent an excess of fines being drawn to the surface. Troweling shall produce a dense, smooth, uniform surface free from blemishes and trowel marks.

3-4.04. Application of Evaporation Reducer. Concrete flatwork subject to rapid evaporation due to hot weather, drying winds, and sunlight shall be protected with an evaporation reducer. The evaporation reducer shall form a continuous film on the surface of fresh, plastic concrete to reduce evaporation.

Immediately following screeding, evaporation reducer shall be sprayed over the entire surface of fresh, plastic concrete flatwork at a rate of not less than 200 square feet per gallon [4 m^2/L], in accordance with the manufacturer's recommendations. The spray equipment shall have sufficient capacity to continuously spray the product at approximately 40 psi [275 kPa] with a suitable nozzle as recommended by the manufacturer.

The sprayable solution shall be prepared as recommended by the manufacturer.

Under severe drying conditions, additional applications of evaporation reducer may be required following each floating or troweling, except the last finishing operation.

3-4.05. Pavement. Following placement and consolidation, and the disappearance of bleed water, the concrete surface shall be drag finished, using a seamless strip of damp burlap over the full width of the surface. The burlap drag shall consist of sufficient layers of burlap and shall have sufficient length in contact with the concrete to slightly groove the surface. The drag shall be moved forward with a minimum bow of the lead edge. The drag shall be kept damp,

clean, and free of particles of hardened concrete. When acceptable to Engineer, carpet, artificial turf, or cotton fabric may also be used.

3-4.07. Sidewalks. Concrete surfaces shall be screeded to the proper elevation and contour. All aggregates shall be completely embedded in mortar. Screeded surfaces shall be given an initial float finish as soon as the concrete has stiffened sufficiently for proper working. Any piece of coarse aggregate which is disturbed by the float or which causes a surface irregularity shall be removed and replaced with mortar. Initial floating shall produce a surface of uniform texture and appearance, with no unnecessary working of the surface. Initial floating shall be followed by a second floating at the time of initial set.

Floated surfaces shall be given a light broom finish, using a horsehair broom, to provide a nonslip surface. Brooming shall be done at right angles to the length of the walk.

Sidewalks shall be edged using a 3 or 4 inch [75 or 100 mm] wide edging tool with a 1/8 inch [3 mm] corner radius. Edger lap marks at corners of each slab shall be carefully removed. False joints shall be provided at right angles to the length of the walk, using a grooving tool with 1/8 inch [3 mm] radius. The finished edge on each side of the joint shall be the same width as the edging tool used. False joints shall divide each sidewalk into square sections.

The finished surface of all sidewalks shall be neat in appearance, shall be sloped to drain, and shall not pond water.

3-5. CURING. Concrete shall be protected from loss of moisture for at least 7 days after placement unless indicated otherwise. Curing of concrete shall be done by methods which will keep the concrete surfaces adequately wet for the specified curing period.

3-5.01. Water Curing. Water curing shall be performed for concrete in liquid-containing structures and for all concrete containing slag cement. Other forms of curing will not be acceptable in these applications. Water curing shall be in accordance with ACI 308.1 except as modified herein.

Water saturation of concrete surfaces shall begin as soon as possible after initial set. The rate of water application shall be regulated to provide complete surface coverage with a minimum of runoff.

Water curing shall continue for 14 days for concrete containing slag cement, and for 7 days for other types of concrete. However, when concrete is being protected from low temperatures, the duration of water curing may be shortened to 1 day less than the duration of cold weather protection.

When forms are removed before the specified curing duration is completed, measures shall be taken to immediately continue water curing and to provide adequate thermal protection for the concrete.

3-5.02. Membrane Curing. Unless otherwise specified, membrane curing compound may be used instead of water curing on concrete in non-liquid-containing structures which will not be stained or etched, covered with chemical resistant linings, covered with additional concrete, or indicated in the Architectural drawings to be covered with a finish flooring material.

Membrane curing compound shall be evenly sprayed at a coverage rate of not more than 300 square feet per gallon [7.3 m^2/L]. The spray equipment shall have sufficient capacity to continuously spray curing compound at approximately 40 psi [275 kPa] with a suitable nozzle as recommended by the manufacturer. Unformed surfaces shall be covered with the first coat of curing compound within 30 minutes after final finishing. A second coat of curing compound shall be applied when the first coat has become tacky to the touch and shall be applied at right angles to the first coat.

Curing compound shall be suitably protected against abrasion during the curing period.

3-5.03. Film Curing. Unless otherwise specified, film curing with white polyethylene sheeting may be used instead of water curing on concrete in nonliquid-containing structures which will be covered later with mortar or additional concrete, or which will otherwise not be exposed to view.

Film curing shall begin as soon as possible after initial set of the concrete. The concrete surfaces shall be completely covered with polyethylene sheeting. Sheeting shall overlap the edges of the concrete for proper sealing and anchorage, and joints between sheets shall be sealed. All tears, holes, and other damage shall be promptly repaired. Covering shall be anchored continuously at edges and as necessary to prevent billowing on the surface.

3-6. REPAIRING DEFECTIVE CONCRETE. Defective concrete shall be defined as any surface with undesirable visible effects in excess of that permitted by the relevant formed concrete surface category (CSC), except as indicated otherwise herein.

Defects in formed concrete surfaces shall be repaired to the satisfaction of Engineer within 24 hours of form removal. Surface repair work shall conform to Article 5.3.7 of ACI 301 and shall be performed in a manner that will not interfere with thorough curing of the surrounding concrete. Surface repair material shall be adequately cured.

Defects in concrete that are more than 3 inches [75 mm] deep shall be brought to the attention of Engineer prior to any repair work. Contractor shall submit a proposed repair material and procedure for review by Engineer. The repair material and procedure required by Engineer may be more extensive than the process described in Article 5.3.7 of ACI 301.

3-7. OWNER'S FIELD CONTROL TESTING. Field control tests shall be performed by Engineer or Owner's testing laboratory personnel, at the expense of Owner. Contractor shall provide access to all facilities and the services of one or more employees as necessary to assist with the field control testing.

3-7.01. Air Content. An air content test shall be made on concrete from each batch of concrete from which concrete compression test cylinders are made. Air content shall be determined in accordance with ASTM C231.

3-7.02. Slump. A slump test shall be made on concrete from each batch of concrete from which concrete compression test cylinders are made. Slump shall be determined in accordance with ASTM C143.

3-7.03. Test Cylinders. Compression test specimens shall be made, cured, stored, and delivered to the laboratory in accordance with ASTM C31 and C39. Compressive strength tests will be evaluated in accordance with ACI 318 and as specified herein.

One set of concrete test cylinders shall be cast for each concrete pour. A set of test cylinders shall consist of four or six cylinders depending on the cylinder size selected. Half of the cylinders shall be tested at 7 days, and the remaining half shall be tested at 28 days. All concrete required for testing shall be furnished by, and at the expense of, Contractor.

TABLE 1 – LIMITING REQUIREMENTS					
	Concrete Class	**A**	**B**	**C**	**D**
1.	**Minimum Cement Content**, lbs/cubic yard; based on maximum slump and maximum water-cementitious material ratio.				
	Maximum Nominal Aggregate Size, ASTM C33 aggregate				
	Size No. 467 (1-1/2")	489	464	---	380
	Size No. 57 (1")	514	489	460	400
	Size No. 67 (3/4")	526	514	480	420
	Size No. 7 (1/2")	555	526	500	440
	Size No. 8 (3/8")	564	555	520	460
	Fine Aggregate, (Sand)	---	---	---	---
2.	**Compressive Strength**, minimum; psi				
	Field, 7 days;	3375	3000	2250	1500
	Field, 28 days; f'_c	4500	4000	3000	2000
	Laboratory, 28 days; f'_{cr}	5700	5200	3200	2000
3.	**Maximum water-cementitious material ratio**	0.45	0.48	0.65	0.75
4.	**Maximum nominal coarse aggregate size, inches**	1-1/2	1-1/2	1	1-1/2
5.	**Maximum slump, inches**				
	Slump before super-plasticizer added	4	4	5	6
	Slump after adding superplasticizer	8	8	8	10
6.	**Total air content**, percent, (± 1.5 %)	6	6	---	---
7.	**Fly ash replacement, percent range**	15-25	15-25	15-30	15-30
8.	**Slag cement replacement, percent range**	25-50	25-30	25-50	25-50
9.	**Testing limits**				
	Sand equivalent, min. percent	75	75	---	---
TABLE 1 – LIMITING REQUIREMENTS					

	Concrete Class	**A**	**B**	**C**	**D**
	Chloride ion, max. percent	0.15	0.15	0.30	---
	Shrinkage, max. percent; based 4 x 4 x 11 inch specimen				
	Laboratory	0.048	0.048	---	---
	Field	0.064	0.064	---	---
	Coarse Aggregate: Clay and shale combined particles shall not exceed, max. percent	1	3	10	3
10	**Concrete temperature at time of delivery and placement, max. °F**	90	95	95	95

TABLE 2A – SUBMITTAL REQUIREMENTS (PRELIMINARY REVIEW OF MATERIALS)					
	Concrete Class	**A**	**B**	**C**	**D**
1	**Aggregate reports** (ASTM C33)				
	Fine aggregate				
	Source and type	**X**	**X**	**X**	**X**
	Gradation	**X**	**X**	**X**	**X**
	Deleterious materials	**X**	**X**	**X**	**X**
	Fineness modulus	**X**	**X**	**X**	**---**
	Alkali-aggregate reactivity	**X**	**X**	**X**	**X**
	Sand equivalent	**X**	**X**	**X**	**---**
	Coarse aggregate				
	Source and type	**X**	**X**	**X**	**X**
	Gradation	**X**	**X**	**X**	**X**
	Deleterious materials	**X**	**X**	**X**	**X**
	Abrasion loss	**X**	**X**	**X**	**---**
	Soundness test	**X**	**X**	**X**	**---**
	Alkali-aggregate reactivity	**X**	**X**	**X**	**X**
	Combined aggregate gradation	**X**	**X**	**X**	**X**
2	**Cement**, mill report	**X**	**X**	**X**	**X**
3	**Cementitious material**, type, data sheet, and test report (fly ash, slag cement)	**X**	**X**	**X**	**X**
4	**Admixtures**				
	Data sheets and certifications	**X**	**X**	**X**	**X**
	Manufacturer's approval letter	**X**	**X**	**X**	**X**
5	**NSF 61 compliance**, for each proposed concrete constituent, where applicable	**---**	**---**	**---**	**---**

TABLE 2B – SUBMITTAL REQUIREMENTS (PROPOSED MIXTURE PROPORTIONS)					
	Concrete Class	**A**	**B**	**C**	**D**
6	**Mixture proportions**, reports	**X**	**X**	**X**	**X**

TABLE 2C – SUBMITTAL REQUIREMENTS (MIXTURE TESTING)					
	Concrete Class	**A**	**B**	**C**	**D**
7	**Type of testing**				
	Field test records acceptable	---	---	---	**X**
	Trial mixtures required	**X**	**X**	**X**	---
8	**Test Reports Required**				
	Confirmation of materials tested				
	Cement brand, type, composition, quantity	**X**	**X**	**X**	**X**
	Fly ash brand, type, composition, quantity	**X**	**X**	**X**	**X**
	Specific gravity of each aggregate	**X**	**X**	**X**	**X**
	Ratio of fine to total aggregates	**X**	**X**	**X**	---
	Water content	**X**	**X**	**X**	**X**
	Water-cementitious materials ratio	**X**	**X**	**X**	**X**
	Slump	**X**	**X**	**X**	---
	Unit weight	**X**	**X**	**X**	---
	Air content	**X**	**X**	**X**	---
	Temperature	**X**	**X**	**X**	---
	Time of initial set at 70°F and 90°F.	**X**	**X**	**X**	---
	Three point curves	**X**	---	**X**	---
	Compressive strength at 7 and 28 days	**X**	**X**	**X**	**X**
	Water-soluble chloride ion	**X**	**X**	**X**	**X**

TABLE 2C – SUBMITTAL REQUIREMENTS (MIXTURE TESTING)					
	Concrete Class	**A**	**B**	**C**	**D**
	Drying shrinkage	**X**	**X**	**X**	**---**
	NSF 61 compliance evaluations where applicable	**---**	**---**	**---**	**X**

End of Section

Section 03600

GROUTING

PART 1 - GENERAL

1-1. SCOPE. This section covers procurement and installation of grout. Unless otherwise specified, only nonshrink grout shall be furnished.

Epoxy grouting and adhesive anchoring of anchor bolts, threaded rod anchors, and reinforcing bars is covered in the Anchorage in Concrete and Masonry section. Grouting of masonry is covered in the Masonry section.

1-2. SUBMITTALS. A letter of certification indicating the types of grout to be supplied and the intended use of each type shall be submitted in accordance with the Submittals Procedures section.

1-3. DELIVERY, STORAGE, AND HANDLING. Materials shall be handled, transported, and delivered in a manner which will prevent damage of any kind. Materials shall be protected from moisture.

PART 2 - PRODUCTS

2-1. MATERIALS.

Nonshrink Grout	Precision cementitious grout with demonstrated non-shrinking properties, minimum 28 day compressive strength of 9000 psi; L&M "Crystex", BASF "Masterflow 928”, Sika “SikaGrout 328”, or Dayton Superior "Sure-Grip High Performance Grout".
Water	Clean and free from deleterious substances.

2-2. CEMENTITIOUS GROUT. Cementitious grout shall be furnished factory premixed so that only water is added at the jobsite.

2-3. EPOXY GROUT. Epoxy grout shall be used in lieu of cementitious grout when required by the equipment manufacturer for performance or warranty requirements. Epoxy grout shall be a three component system consisting of a Part A (resin), Part B (hardener) and Part C (aggregate). All three components shall be products of the same manufacturer and be compatible. Epoxy grout products and installation procedures shall be submitted to Engineer for approval.

PART 3 - EXECUTION

3-1. CEMENTITIOUS GROUT INSTALLATION.

3-1.01. Preparation. The concrete foundation to receive cementitious grout shall be saturated with water for at least 12 hours preceding grouting unless additional time is required by the grout manufacturer.

3-1.02. Mixing. Grout shall be mixed in a mechanical mixer. No more water shall be used than is necessary to produce a flowable grout, nor shall water content exceed the amount recommended by the manufacturer.

3-1.03. Temperature Restrictions. Grout shall be placed in accordance with the manufacturer's published temperature restrictions. Ambient temperature and grout temperature shall be a minimum of 40 degrees F and rising at time of placement. Grout shall not be placed on frost covered surfaces. Grout shall be protected from freezing until it has reached a minimum strength of 4,000 psi. Grout shall not be placed when the ambient or grout temperature exceeds 90 degrees F.

3-1.04. Placement. Unless otherwise specified or indicated on the Drawings, grout under baseplates shall be 1-1/2 inches [38 mm] thick. Grout shall be placed in strict accordance with the directions of the manufacturer so that all spaces and cavities below the baseplates are completely filled without voids. Forms shall be provided where structural components of baseplates will not confine the grout.

3-1.05. Edge Finishing. In all locations where the edge of the grout will be exposed to view, the grout shall be finished smooth after it has reached its initial set. Except where shown to be finished on a slope, the edges of grout shall be cut off flush at the baseplate.

3-1.06. Curing. Grout shall be protected against rapid loss of moisture by covering with wet cloths or polyethylene sheets. After edge finishing is completed, the grout shall be wet cured for at least 3 days and then an acceptable membrane curing compound shall be applied.

3-2. EPOXY GROUT INSTALLATION. Epoxy grout shall be installed in accordance with ACI 351.5.

End of Section

Section 05810

ANCHORAGE IN CONCRETE AND MASONRY

PART 1 - GENERAL

1-1. SCOPE. This section covers the design and installation of anchors in concrete and masonry. It includes cast-in-place anchor bolts and anchor rods, adhesive anchors for both threaded rods and reinforcing bars, expansion anchors, and undercut anchors.

1-2. GENERAL.

1-2.01. Anchors Designed by Engineer. Cast-in-place and post-installed anchors that are fully detailed on the Drawings have been designed by Engineer, and may not be changed to a different type without written approval of Engineer.

1-2.02. Anchors Designed by Contractor's Suppliers. Contractor's material suppliers shall be responsible for design of anchors for railings, ladders, equipment, pre-engineered structures, and other manufactured items, as indicated in the Drawings and Specifications. Anchors shall be designed for all operating conditions, including wind and seismic loadings when indicated in the Meteorological and Seismic Design Criteria section. Cast-in-place anchors shall be used unless post-installed types are indicated on the Drawings or accepted by Engineer. Adhesive anchors used in vibrating applications, such as for pumps, shall only be used if the manufacturer submits documentation indicating that the product is suitable for the service conditions.

1-2.03. Materials. Unless otherwise indicated, anchors of structural steel members connected to concrete shall have a diameter of at least 3/4 inch, and structural members connected to masonry shall have a diameter of at least 5/8 inch. Anchors for ladders and equipment shall have a diameter of at least 1/2 inch. Anchors for pedestrian railing systems shall have a diameter of at least 3/8 inch.

Unless otherwise indicated on the Drawings, anchors used in the following locations and applications shall be of the indicated materials.

Cast-In-Place Anchor Bolts and Anchor Rods

Submerged locations	Stainless steel.
Locations subject to splashing	Stainless steel.
Buried locations	Stainless steel.

Anchorage of structural steel columns	Galvanized steel.
Other exterior locations	Galvanized steel.
Other interior locations	Carbon steel.

Adhesive, Expansion, and Undercut Anchors

Submerged locations	Stainless steel.
Locations subject to splashing	Stainless steel.
Buried locations	Stainless steel.
Anchorage of structural steel columns	Stainless steel.
Other exterior locations	Stainless steel.
Other interior locations	Carbon steel.

Adhesive, expansion, and undercut anchors may be used instead of cast-in-place anchors only where specifically indicated or permitted on the Drawings or with the specific acceptance by Engineer.

1-3. SUBMITTALS. Data, catalog cuts, and manufacturer's research reports (from independent organizations such as ICC-ES or IAPMO UES) indicating the manufacturer and types of adhesive anchors, expansion anchors, and undercut anchors to be supplied shall be submitted in accordance with the Submittals Procedures section.

If Contractor requests use of products other than those indicated herein, calculations may be required as part of the submittal package. Calculations shall be prepared by a professional engineer licensed in the state of the project, using methods and procedures required by the building code. Contractor shall demonstrate that the proposed substitute anchors are equivalent in all necessary criteria, including strength, spacing and edge distance limitations, embedment depth limitations, temperature limitations, and any other criteria required by Engineer.

1-4. DELIVERY, STORAGE, AND HANDLING. Materials shall be handled, transported, and delivered in a manner which will prevent damage or corrosion. Damaged materials shall be promptly replaced. Materials shall be shipped and stored in original manufacturer's packaging.

PART 2 - PRODUCTS

2-1. MATERIALS. Unless otherwise indicated on the drawings, materials shall be as indicated below.

Cast-In-Place Anchor Bolts and Anchor Rods	
Carbon steel	ASTM F1554, Grade 36 with compatible nuts.
Galvanized steel	ASTM F1554, Grade 36 with compatible nuts; hot-dip galvanized, ASTM F2329.
Stainless steel	Bolts, ASTM F593, Alloy Group 2 (minimum yield strength of 45 ksi); nuts, ASTM F594, Alloy Group 1 or 2.
Flat Washers	ANSI B18.22.1; of the same material as anchor bolts and nuts.
Expansion Anchors in Concrete	Products shall be single component anchors tested in accordance with ICC AC193, and shall have a manufacturer's research report in compliance with the applicable building code. The anchors shall be approved for use in cracked concrete, and for resisting seismic forces. Hilti "Kwik-Bolt TZ" or Powers Fasteners "Power-Stud+SD2" (carbon steel), "Power-Stud+SD4" (304 stainless steel), and "Power-Stud+SD6" (316 stainless steel).
Expansion Anchors in Grouted Concrete Masonry Units	Products shall be single component anchors tested in accordance with ICC AC01, and shall have a manufacturer's research report in compliance with the applicable building code. Hilti "Kwik-Bolt TZ Masonry Anchors", Simpson "Wedge-All", or Powers Fasteners "Power-Stud+ SD1".

Undercut Anchors in Concrete	Products shall be tested in accordance with ICC AC193, and shall have a manufacturer's research report in compliance with the applicable building code. Hilti "HDA Undercut Anchor" (carbon steel) and "HDA-R Undercut Anchor" (stainless steel), or Powers Fasteners "Atomic+ Undercut Anchor" (A36 carbon steel).
Adhesive Anchors in Concrete	Products shall be tested in accordance with ICC AC308, and shall have a manufacturer's research report in compliance with the applicable building code. The anchors shall be approved for use in cracked concrete, and for resisting seismic forces.
Threaded Rods and Nuts (Carbon Steel)	ASTM A307 or ASTM F1554 Grade 36.
Threaded Rods and Nuts (Carbon Steel)	ASTM F593, CW.
Reinforcing Bars	ASTM A615, Grade 60, deformed.
Reinforcing Bars, weldable	ASTM A706, Grade 60, deformed.
Adhesive	Hilti "HIT-HY 200", or Powers Fasteners "Pure 110+".
Adhesive Anchors in Grouted Concrete Masonry Units	Products shall be tested in accordance with ICC AC58, and shall have a manufacturer's research report in compliance with the applicable building code.
Threaded Rods and Nuts (Carbon Steel)	ASTM A307 or ASTM F1554 Grade 36.
Threaded Rods and Nuts (Stainless Steel)	ASTM F593 CW (Hilti or Powers systems), or ASTM A193 Grades B6, B8, or B8M (for Simpson system).
Adhesive	Hilti "HIT HY 70", Powers "AC100+ Gold", or Simpson "SET XP".

Adhesive Anchors in Hollow Concrete Masonry Units	Products shall be tested in accordance with ICC AC58, and shall have a manufacturer's research report in compliance with the applicable building code.
Threaded Rods and Nuts (Carbon Steel)	ASTM A307 or ASTM F1554 Grade 36.
Threaded Rods and Nuts (Stainless Steel)	ASTM F593 CW (Hilti or Powers systems), or ASTM A193 Grades B6, B8, or B8M (for Simpson system).
Adhesive	Hilti "HIT HY 70", Powers "AC100+ Gold", or Simpson "SET XP".
Screen Tubes	As recommended by the manufacturer.
Adhesive Anchors in Unreinforced Brick Masonry	Products shall be tested in accordance with ICC AC60, and shall have a manufacturer's research report in compliance with the applicable building code.
Threaded Rods and Nuts	ASTM A307.
Adhesive	Hilti "HIT HY 70", Simpson "SET".
Screen Tubes	As recommended by the manufacturer.

2-2. ANCHORS.

2-2.01. Cast-in-Place Anchor Bolts and Anchor Rods. Cast-in-place anchor bolts and anchor rods shall have forged heads or embedded nuts and washers. Anchors shall be delivered in time to permit setting prior to the placing of structural concrete or masonry grout. Anchor sleeves shall not be used unless acceptable to Engineer. Unless installed in sleeves, anchor bolts and anchor rods shall be provided with sufficient threads to permit a nut to be installed on the concrete side of the concrete form or the supporting template. Two nuts, a jam nut, and a washer shall be furnished for cast-in-place anchor bolts and anchor rods indicated on the Drawings to have locknuts; two nuts and a washer shall be furnished for cast-in-place anchor bolts and anchor rods without locknuts.

2-2.02. Adhesive, Expansion, and Undercut Anchors. When adhesive, expansion, or undercut anchors are indicated on the Drawings, only acceptable systems shall be used. Acceptable systems shall include only those systems

and products specified or specifically indicated by product name on the Drawings. Alternative anchoring systems may be used only when specifically accepted by Engineer.

Unless otherwise noted, single nuts and washers shall be provided with adhesive anchors, expansion anchors, and undercut anchors. Adhesive anchors shall be free of coatings that would weaken the bond with the adhesive.

Adhesive anchors in hollow CMU masonry and unreinforced brick masonry shall utilize screen tubes as recommended by the manufacturer.

PART 3 - EXECUTION

3-1. GENERAL. Anti-seize thread lubricant shall be liberally applied to projecting, threaded portions of stainless steel anchors immediately before tightening of the nuts.

3-1.01. Compliance With Manufacturer's Instructions. Post-installed anchors shall be installed in accordance with the manufacturer's printed installation instructions and all applicable requirements of the manufacturer's research report for the specific anchor system. If conflicts are found between the Drawings, the manufacturer's printed installation instructions, and the manufacturer's research report installation requirements, Contractor shall notify Engineer for resolution.

3-1.02. Special Inspection. Special inspection requirements for cast-in-place and post-installed anchors shall be as indicated in the Code-Required Special Inspections and Procedures section. Anchorage work shall be performed in a manner that allows the inspections to take place without adversely impacting the schedule.

3-2. CAST-IN-PLACE ANCHOR BOLTS AND ANCHOR RODS. Cast-in-place anchor bolts and anchor rods shall be carefully positioned with templates and secured in the forms prior to placing concrete, or in masonry bond beams prior to placing grout. Contractor shall verify that anchorage devices are positioned in accordance with the Drawings and with applicable equipment or structure submittal drawings.

Threads, bolts, and nuts spattered with concrete or masonry grout during placement shall be cleaned prior to final installation of the bolts and nuts.

Sleeves shall be filled with non-shrink grout.

3-3. ADHESIVE ANCHORS. Adhesive shall be statically mixed in the field during application. All proportioning and mixing of the components shall be in accordance with the manufacturer's recommendations.

Anchors or bars shall be installed in holes hammer drilled into hardened concrete or masonry. Drill shall be set to rotation-only mode when drilling into hollow CMU or into brick. Diameter of holes shall be 1/16 inch larger than the outside diameter of the rod or bar unless recommended otherwise by the anchor system manufacturer. Holes shall be prepared by removing all dust and debris using procedures recommended by the adhesive manufacturer.

Adhesive anchors and holes shall be clean, dry, and free of grease and other foreign matter at the time of installation. The adhesive shall be placed and the rods or bars shall be set in accordance with the recommendations of the manufacturer. Care shall be taken to ensure that all spaces and cavities are filled with adhesive, without voids.

3-3.01. Concrete Installation. Unless indicated otherwise on the Drawings, reinforcing bars shall be embedded to a depth of 15 bar diameters, and threaded rods shall be embedded to a depth that will develop the yield strength of the rod.

Adhesive anchors in concrete shall be installed under the following conditions.

Minimum Age of Concrete Prior to Anchor Installation	21 days.
Concrete Temperature Range	Maximum short-term temperature 162 F, maximum long-term temperature 110 F.
Moisture Condition	Dry concrete.
Type of Lightweight Concrete	N/A
Hole Drilling and Preparation	Hammer drill only.

Installation of adhesive anchors into concrete that are either horizontal or upwardly inclined shall be performed only by personnel certified by the ACI/CRSI Adhesive Anchor Installation Certification Program.

3-3.02. Masonry Installation. Anchors shall be installed to meet all criteria in the manufacturer's installation instructions and ICC-ES reports, including but not limited to minimum compressive strength at time of installation, minimum edge distances, minimum clearances from mortar joints, minimum anchor spacing, and use of screen tubes.

3-4. EXPANSION AND UNDERCUT ANCHORS. Expansion and undercut anchors shall be installed using all procedures and accessory devices recommended by the anchor manufacturer.

End of Section