SECTION 32 32 13
PORTLAND CEMENT CONCRETE RETAINING WALLS
Construction Specification

PART 1 GENERAL

1.1 PURPOSE:

A. This section describes general requirements, products, and methods of execution relating to on-site Portland Cement Concrete Retaining Walls, unless otherwise noted:

1. Concrete mix design.

2. Formwork.

3. Reinforcement.

4. Removal of unused concrete and materials.

B. Contractor shall provide all labor, equipment, materials, and testing services unless otherwise noted.

C. Related Sections:

1. Section 31 10 00 - Site Preparation.

2. Section 31 23 33 – Trenching, Backfilling, & Compacting.

D. San Mateo County Community College District is strongly committed to promoting sustainability throughout their campus projects. Section 01 81 13 Sustainability of the Design Standard provides guidelines and recommendations for implementing sustainability strategies. Where relevant, specific sustainability criteria is noted in this section; however, each project team should review and cross reference that front section while developing the specific project and its documentation. Each discipline shall confirm that specific performance and manufacturer information provided in the specification section is in alignment with code requirements, LEED criteria, and any other goals for sustainability.

1.2 SUBMITTALS

A. Comply with requirements of Section 01 33 00 Submittals.

B. Submit product data for proprietary materials and items, admixtures, joint systems, curing compounds, dry-shake finish materials, source of concrete and aggregates, and others if requested by District.

C. Submit design mixes for each class of concrete. Include revised mix proportions when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.

D. Submit laboratory test reports for evaluation of concrete materials and mix design tests.

E. Provide material certificates in lieu of material laboratory test reports when permitted by Architect.

1. Provide material certificates signed by manufacturer and Contractor certifying that each material item complies with or exceeds requirements.

2. Provide certification from admixture manufacturers that chloride content complies with requirements.

F. Shop Drawings: Submit shop drawings showing elevations, control joint layout, finish, and rebar schedule.

1.3 QUALITY ASSURANCE

A. Comply with latest edition of the following standards and regulations:

1. American Society for Testing and Materials (ASTM).

2. California Department of Transportation (CALTRANS) Standard Plans (CSP) and Standard Specifications (CSS).

3. American Concrete Institute (ACI).

4. Local requirements where they are applicable.

B. Prevent damage to adjacent concrete curbs, walks, utilities, walls, City of San Bruno Water District landscape mitigation area, etc., during installation.

1. Repair any damage to concrete edges or breaks in concrete at no cost to the District, by removal and replacement of complete sections.

2. Patching will not be acceptable.

C. The sequence of operations shall be reviewed by the District's Representative prior to commencement of any work.

1.4 SITE CONDITIONS

A. Submit to District in writing any discrepancy between existing conditions and the Contract Documents.

B. Commencement of any part of the work shall constitute acceptance of existing site conditions as satisfactory.

C. Provide protection of materials if required by weather conditions so as not to compromise the quality of work.

D. Provide protection of surfaces adjacent to work.

E. Traffic Control: Maintain access for vehicular and pedestrian traffic as required by District.

PART 2 PRODUCTS

2.1 CONCRETE

A. Provide concrete materials conforming to the applicable requirements for Portland Cement Concrete as specified in CSS Section 90 Portland Cement Concrete (P.C.C.) for ASTM Type II P.C.C., Class 1 Concrete.

1. Concrete shall not contain less than 675 lb of Portland cement per cubic yard.

2. Concrete shall have a 3000 psi, 28-day compressive strength.

3. Concrete shall have a water-cement ratio of 0.44 maximum (non-air-entrained), or 0.35 maximum (air-entrained).

4. Mix design adjustments may be requested when materials, job conditions, weather, test results, or other circumstances warrant adjustment. Laboratory tests must be submitted to and accepted by the District's representative before using in work.

B. Aggregate for normal weight concrete shall be free of deleterious material and conform to CSS Section 90-3.04, 1-1/2 inch maximum grading.

1. Coarse Aggregate shall conform to CSS Section 90-2.02A.

2. Fine Aggregate shall conform to CSS Section 90-2.02B.

C. Water: Water shall be clean and potable, and free from oil, acid, alkali, organic matter or other deleterious substances.

D. Admixtures: Admixtures may be used with approval of the Engineer. If more than one admixture is used, Contractor shall certify that all admixtures are compatible. Admixtures shall conform to CSS Section 90-4. Admixtures shall not impair the strength of the concrete, and is not to be used to reduce the cement content if the mix.

E. Slump Limit: Slump shall be not less than 1 inch and not more than 4 inches.

F. Patching Mortar: Mortar shall conform to CSS Section 51-1.135. Color shall match surrounding concrete.

G. Grout: Grout shall be factory pre-mixed conforming to ASTM C1107, Grade B, capable of developing 2400 psi in 48 hours, 7000 psi in 28 days.

2.2 FORMS

A. General: Provide forms of wood or steel, straight and of sufficient strength and stiffness to resist springing during depositing and consolidating concrete, of a height equal to the full depth of the finished concrete, and conforming to CSS Section 51.105 Forms, unless otherwise specified.

B. Wood forms:

1. Use minimum 5/8-inch thick plywood complying with U.S. Product Standard PS 1 for s for Concrete Form plywood for exposed surfaces.

2. Wood forms for exposed surfaces shall be straight and free from warp, twist, loose knots, splits or other defects.

3. Wood forms for unexposed surfaces shall be of sufficient strength and stiffness to hold concrete properly in place.

C. Steel forms:

1. Provide channel-formed sections with a flat top surface and with welded braces at each end and at not less than 2 intermediate points.

2. Form ends shall be interlocked and self-aligning.

3. Forms shall include flexible forms for radius forming, corner forms, form spreaders, and fillers.

4. Stake pins shall be solid steel rods with chamfered heads and pointed tips, designed for use with steel forms.

D. Form ties: Form ties shall be snap-off metal of fixed length, leaving no metal within 1-1/2 inch of surface and no fractures or other surface defects larger than 1 inch in diameter. Manufactured by Burke, Dayton, or approved equivalent.

E. Chamfer strips: Chamfer strips shall be rigid PVC, 3/4 inch x 3/4 inch or 1 inch x 1 inch size, as indicated on the Plans.

F. Form release agent: Form release agent shall be a colorless, non-staining agent, free from oils, that shall not impair bonding of paint or other coatings.

2.3 OTHER MATERIALS

A. Concrete Curing Material:

1. Burlap: Conforming to AASHTO M182 with a weight of 14 ounces or more per square yard when dry.

2. Impervious Sheeting: Comply with ASTM C171.

3. Liquid Membrane Curing Compound: Comply with ASTM C309. Provide curing compound free of paraffin or petroleum.

B. Expansion Joint Fillers: Comply with ASTM D1751 or provide a resin-impregnated fiberboard conforming to the physical requirements of ASTM D1752.

C. Reinforcement: Provide dowels, reinforcement bars and welded wire mesh conforming to the requirements in CSS Section 52, Reinforcement, as required in the Plans.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine the surfaces and areas at the locations for the retaining walls to establish acceptable conditions.

1. Examine areas where formwork will be constructed and verify that:

a. The excavations are sufficient to permit placement, inspection, and removal of forms.

b. The excavations for earth forms have been neatly and accurately cut.

c. Conditions are otherwise proper for formwork construction.

2. Verify that formwork is complete.

3. Verify that the excavation is free of debris and excess water.

B. Coordinate size and location of openings and penetrations in the concrete.

C. Coordinate location of items to be embedded into the concrete.

D. If unsuitable conditions are found, immediately notify the District's Representative in writing, indicating the nature and extent of the unsuitable conditions.

E. Do not begin installation until defects have been corrected.

3.2 SUBGRADE PREPARATION

A. Remove material deflecting more than 1/2 inch under the roller to a depth of 4 inches. below subgrade elevation and replace with an approved granular material.

1. Compact new material as specified in Section 31 23 33 – TRENCHING, BACKFILLING, & COMPACTING, or as shown in the Construction Documents.

2. Test completed subgrade for grade and cross section with a template extending the full width of the footing and supported between side forms.

3. Provide subgrade of materials equal in bearing quality to the subgrade under the adjacent pavement.

4. Place and compact additional subgrade material as needed.

B. Maintenance of Subgrade:

1. Maintain subgrade in a smooth, compacted condition, in conformity with the required section until the concrete is placed.

2. Prepare and protect subgrade so as to produce a subgrade free from frost and excessive moisture when the concrete is deposited.

3.3 FORM SETTING

A. Construct formwork to produce concrete surfaces to the tolerances of ACI 301.

B. Provide temporary ports in formwork to facilitate cleaning and inspections. Locate openings at the bottom or forms to allow flushing water to drain. Close ports with tight-fitting panels, flush with the inside face of the forms, neatly fitted so that joints will not be apparent in exposed concrete surfaces.

C. Provide chamfer strips on external corners of walls.

D. At exposed surfaces, keep the number of panel joints to a practical minimum. Insure vertical joints are plumb and horizontal joints are level.

E. After forms are set, check grade and alignment with a 10-foot straightedge.

1. Forms shall conform to line and grade with an allowable tolerance of 1/4 inch in any 10-foot long section.

2. Forms shall have a transverse slope with the low side adjacent to the roadway unless otherwise indicated on Drawings.

F. Form release agent:

1. Apply a coating of form release agent immediately before use, but prior to installation of reinforcing steel and embedded items.

2. Do not apply agent where concrete surfaces are scheduled to receive special finishes which may be affected by the agent.

3. Soak contact surfaces of untreated forms with clean water.

G. Embedded parts and openings:

1. Provide formed openings for work passing through concrete where indicated on Electrical drawings.

2. Do not install sleeves or openings, except as indicated on the Plans, without approval of the Engineer.

3. Properly locate and place inserts and embedded items required by work prior to casting concrete.

H. Expansion Joints:
Provide expansion joints and isolation joints where shown or noted on the Plans.

1. Provide sealed joints where concrete surface remains exposed to view or at conditions with non-bituminous or liquid waterproofing, unless otherwise shown or noted.

2. Place joint filler in straight line with edge held back to specified dimension from finish surface and secure to formwork or previously placed construction.

3. Use fiber type joints typically and hold edge back 1/4 inch from concrete surface.

4. Use cork type joint fillers at sealed joints and hold edge back 1/2 inch.

5. After curing concrete, carefully clean, prime and fill joints with sealant to 1/4 inch from the finished surface in accordance with manufacturer's recommendations.

I. Do not remove side forms within 12 hours after finishing has been completed.

3.4 EARTH FORMS

A. Footing forms may be omitted and foundation concrete may be placed directly into neatly and accurately cut excavations, provided that the walls are stable as determined by the Geotechnical Engineer, subject to approval by the Engineer.

B. Where sides are deemed unstable or excavations are not accurately cut to tolerances of ACI 301, construct forms to the extent required.

C. Remove loose dirt prior to placing concrete.

3.5 FORM REMOVAL

A. Do not remove forms until concrete has hardened and attained sufficient strength to permit safe removal and adequate support of adjacent loads.

B. Remove forms carefully to avoid damaging corners and edges of exposed concrete. Prying against the face of concrete is not allowed.

C. Curing, where forms are removed in less than 14 days, shall be continued as follows:

1. Wet down concrete immediately after stripping.

2. Apply curing compound as soon as areas are surface dry.

D. After concrete is placed, forms and shores shall remain in place for not less than 7 days for wall forms and 3 days for side forms of slabs and foundations.

3.6 REUSE OF FORMS

A. The District's Representative will approve reuse of forms. Forms shall be straight, clean,

free from nails, hardened concrete, and other deleterious matter. Edges and surfaces should be in good condition.

B. Clean and repair all damage caused by placing, removal, or storage. Reuse of formwork with patches or repairs that could affect the exposed concrete finish will not be permitted.

C. Forms shall not be reused for Architectural Concrete if there is any evidence of surface damage or defect which could affect the quality of the surface.

D. Reseal form faces as required to achieve concrete of specified quality.

3.7 REINFORCEMENT PLACEMENT

A. Place bars at locations shown on the Plans, maintaining minimum cover, to the following tolerances:

1. Clear distance to formed surfaces: Plus or minus 1/4 inch.

2. Top bars in slabs 8 inches deep or less: Plus or minus 1/4 inch.

3. Tops bars in beams and slabs over 8 inches deep: Plus 1/4 inch and minus 1/2 inch.

4. Bar Spacing: Plus or minus one inch, but not less than minimum spacing.

5. Ends of Bars: Plus or minus 2 inches, except plus or minus 1/2 inch at discontinuous ends.

B. Comply with Concrete Reinforcing Steel Institute's recommended practice for "Placing Reinforcing Bars," for details and methods of reinforcement placement and supports, and as herein specified.

C. Clean reinforcement of loose rust and mill scale, earth, ice, and other bond-reducing materials.

D. Locate and support reinforcing by metal chairs, runners, bolsters, spacers, and hangers.

E. Accurately position, support and secure reinforcement against displacement by formwork, construction, or concrete placement operations.

F. Place reinforcement to obtain at least minimum coverage for concrete protection.

1. Arrange, space and securely tie bars and bar supports to hold reinforcement in position during concrete placement operations.

2. Set wire ties so ends are directed into concrete, not toward exposed concrete surfaces.

G. Reinforcement to be welded shall conform to requirement of American Welding Society Specifications, AWS D12.1.

1. If mill test reports are not available, chemical analysis shall be made of bars representative of the bars to be welded.

2. ASTM A706 bars may be assumed to have a carbon equivalent (C.E.) not exceeding 0.55. Bars with a C.E. above 0.75 shall not be welded.

3. Welding shall not be done on or within two bar diameters of any bent portion of a bar which has been bent cold.

4. Welding of crossing bars shall not be permitted for assembly of reinforcement unless authorized by the Structural Engineer of Record and approved by the Inspector of Record.

5. Welding is not permitted unless specifically detailed on plans or approved by Architect.

H. Splicing: Make splices only at those locations shown on the Plans or as accepted by the Owner's Representative. Stagger splices in adjacent bars wherever possible.

I. Dowels: Dowels shall be tied securely in place before concrete is deposited. In the event there are no bars in position to which dowel may be tied, No. 3 bars (minimum) shall be added to provide proper support and anchorage.

J. Install deformed bar anchors in accordance with the manufacturer's recommendations.

K. Install mechanical splices and reinforcing couplers in accordance with manufacturer's recommendations.

L. Reinforcement shall not be bent after being embedded in hardened concrete.

M. Protection Against Rust

1. Where there is danger of rust staining adjacent surfaces, wrap reinforcement with impervious tape or otherwise prevent rust staining.

2. Remove protective materials and clean reinforcement as required before proceeding with concrete placement.

3.8 CONCRETE PLACEMENT

A. Placing Record: Record time, date and location of concrete placement; maintain record open to inspection by the Inspector-of-Record.

B. Have reinforcement inspected and approved by project structural engineer before depositing concrete.

C. Place concrete in accordance with ACI 301, or CSS Section 51-1.09 Placing Concrete.

D. Convey concrete as rapidly and directly as practicable to preserve quality and to prevent separation.

1. Do not deposit concrete which has initially set.

2. Retempering of concrete which has partially set will not be permitted.

E. The free vertical drop of the concrete deposited at any point in forms during conveying shall not exceed 3 feet. Chutes may be issued only where they discharge into a hopper before distribution.

F. Deposit concrete in a continuous operation to permit proper and thorough integration.

1. Carry work started in a section continuously to construction joint.

2. Place concrete at rate and in such manner that concrete surfaces not carried to joint levels will not attain initial set before additional concrete is placed.

3. Use equipment that will permit the concrete to be placed in a manner that will prevent segregation and accumulations or hardened concrete above the level of the concrete.

G. Keep forms and reinforcement clean above pour line by removing clinging concrete.

H. Cold Weather Placement: Protect concrete work from physical damage or reduced strength which could be caused by frost, freezing, or low temperatures, in compliance with ACI 306 and as herein specified.

1. When air temperature has fallen to or is expected to generally fall below 40 degrees F (4 degrees C), uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 degrees F (10 degrees C), and not more than 80 degrees F (27 degrees C) at point of placement.

2. Thin upper level slabs should obtain a concrete mixture temperature of not less than 55 degrees F (13 degrees C).

3. Do not use frozen materials or materials containing ice or snow.

4. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.

5. Do not use calcium chloride, salt and other mineral containing anti-freeze agents or chemical accelerators, unless otherwise accepted by Architect.

I. Hot Weather Placement: When hot weather conditions exist that would seriously impair quality and strength of concrete, place concrete in compliance with ACI 305 and as herein specified.

1. Cool ingredients before mixing to maintain concrete temperature at time of placement below 90 degrees F (32 degrees C). Mixing water may be chilled, or chopped ice may be used to control concrete temperature provided water equivalent of ice is calculated to total amount of mixing water.

2. Place concrete immediately upon delivery. Keep exposed concrete surfaces, and formed shaft extensions, moist by fog sprays, wet burlap or other effective means.

3. Do not use retarding admixtures without acceptance of Architect.

J. Consolidation:

1. Use internal vibrators for thorough consolidation of all concrete, in compliance with ACI 309 and as herein specified. Use largest size and most powerful vibrators that can be accommodated in the work.

2. Do not place vibrators against reinforcement, attach to forms, or use to spread concrete.

3. Exposed Concrete: Vibrate with rubber type heads and spade along forms with flat strap or plate.

4. Architectural Concrete:

a. Proper placement and thorough compaction of architectural concrete are critical.

b. Place vibrators in the concrete rapidly to minimize entrapped air between the concrete and the form and to blend the two layers.

c. Insert vibrators in accordance with manufacturer's recommended radius of influence.

d. Use a minimum of three 180-cycle motor-in-head vibrators for concrete placing. Minimum frequency 9,000 impulses per minute, minimum head diameter 1-1/2 inches.

e. Keep vibrator heads a minimum of 2-1/2 inches from the architectural concrete face.

f. If, during the placing operation, there is any delay of more than 15 minutes, the previous lift will be manipulated with the vibrators just prior to the placement of fresh concrete.

3.9 FINISHING

A. Finishes for Formed Surfaces: Exposed surfaces shall be graffiti proof.

1. Rough Formed Finish: Patch tie holes and defects and remove fins exceeding 1/4 inch.

2. Smooth Formed Finish: Patch tie holes and defects, remove all fins, and level all offsets.

3. Scratched finish: After the concrete has been placed, consolidated, struck off, and leveled, the surface shall be roughened with stiff brushes or rakes before final set.

4. Floated Finish: After the concrete has been placed, consolidated, struck off, and leveled, do not work the concrete further until ready for floating.

5. Float with a hand float or with a bladed power trowel equipped with float shoes, or with a powered disc float when the water sheen has disappeared and when the surface has stiffened sufficiently to permit operation.

6. During or after the first floating, check uniformity of the surface place with a 10 foot straightedge applied at not less than two perpendicular angles. Cut down high spots and fill low spots during this procedure to produce a surface within tolerance.

7. Refloat slab immediately to a uniform sandy texture.

B. Broom Finish: Immediately after the concrete has received a float finish as specified it shall be given a coarse transverse scored texture by drawing a broom across the surface. Direction of brooming to be as directed by Architect.

C. Clear or Colored Hardened Finish: After float finishing with a hand float, apply hardener in accordance with manufacturer's recommendations or at a rate of 45 pounds per 100 square feet.

1. Steel trowel to a smooth dense finish.

2. Apply wax sealer and cure in accordance with manufacturer's recommendations.

D. Nonslip Finish: After float finishing apply abrasive grains in accordance with manufacturer's recommendation at a rate of 25 pounds per 100 square feet. Lightly steel trowel to finish.

E. Mineral Aggregate Hardener:

1. Apply hardener where indicated on the Plans, at the rate of 120 pounds per 100 square feet; apply in 2 applications by mechanical spreader.

2. The first shake shall comprise 2/3 of the specified amount of hardener; apply after the

initial floating operation unless climatic conditions dictate earlier application.

3. Float the hardener into slab and then apply the second shake.

4. Float the surface after the second shake to properly bond the hardener to the base concrete slab. Then trowel the surface, at least twice, to a smooth dense finish.

5. Color shall be as selected by the Architect.

6. Field Service shall be provided, upon five days notice, by the manufacturer of the hardener to assist the Contractor in obtaining the maximum benefits of the product under prevailing job site conditions.

F. Schedule of Locations for Concrete Finish Types:

1. Slabs or Stairs to receive toppings and fills: Scratched.

2. Exposed Stair Fills: Nonslip.

3. Exterior Paved Areas: Light Broomed.

4. Formed Surface to receive paint: Smooth Formed.

5. Concealed Concrete Surfaces: Rough Formed.

G. Edge and Joint Finishing:

1. Finish slab edges, including those at formed joints, with an edger having a radius of 1/8 inch.

2. Edge transverse joints before brooming. Brooming shall eliminate the flat surface left by the surface face of the edger.

3. Corner and edges which have crumbled and areas which lack sufficient mortar for proper finishing shall be cleaned and filled solidly with a properly proportioned mortar mixture and then finished.

3.10 CURING AND PROTECTION

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperature in accordance with ACI 308 and as specified herein.

1. Start initial curing as soon as free water has disappeared from concrete surface after placing and finishing concrete. Weather permitting, keep continuously moist for not less than 7 days.

2. Begin final curing procedures immediately following initial curing and before concrete has dried.

3. Continue final curing for at least 7 days in accordance with ACI 301 procedures.

4. Avoid rapid drying at end of final curing period.

B. Curing Methods: Perform curing of concrete by moist curing (Mat Method), by moisture-retaining cover curing (Impervious Sheeting Method), by curing compound (Membrane Curing Method), or by combinations thereof.

1. Mat Method: Provide moist curing by any of the following methods to keep concrete surface continuously wet:

C. Cover concrete continuously with water.

D. Provide a continuous water fog spray.

E. Cover concrete with a saturated absorptive mat. Prior to placing mats on concrete surface, thoroughly wet the exposed surface with water. Cover the entire exposed surface with 2 or more layers of burlap. Mats shall overlap each other at least 6 inches. Continuously keep mats in a saturated condition and in intimate contact with concrete for not less than 7 days.

F. Impervious Sheeting Method: Provide moisture-cover curing as follows:

1. Wet the entire exposed surface with a fine spray of water and then cover with impervious sheeting material.

2. Lay sheets directly on the concrete surface, placed in widest practicable width with sides and ends lapped at least 12 inches when a continuous sheet is not used.

3. Provide impervious sheeting at least 18 inches wider than the concrete surface to be cured.

4. Securely weigh sheeting down with heavy wood planks, or by placing a bank of moist earth along edges and laps in the sheets, or by sealing with waterproof tape or adhesive.

5. Immediately repair any holes or tears in cover during curing period using cover material and waterproof tape.

6. Sheets shall be satisfactorily repaired or replaced if torn or otherwise damaged during curing.

a. The curing sheet shall remain on the concrete surface to be cured for not less than 7 days.

G. Membrane Curing Method: Provide curing compound to slabs as follows:

1. Cover the entire exposed surface with a membrane-forming curing compound.

2. Apply specified curing and sealing compound as soon as final finishing operations are complete (within 2 hours).

3. Apply uniformly in continuous operation by power-spray or roller in accordance with manufacturer's directions, or apply in 2 coats by hand-operated pressure sprayers as recommended by the manufacturer.

4. Apply an additional coat to all surfaces showing discontinuity, pinholes or other defects.

5. Recoat areas subjected to heavy rainfall within 3 hours after initial application.

6. Maintain continuity of coating and repair damage during curing period.

7. Protect concrete surfaces to which membrane-curing compounds have been applied.

8. Any area covered with curing compound and damaged by subsequent construction operations within the 7-day curing period shall be resprayed.

H. Do not use membrane curing compounds on concrete surfaces which are to be covered with material applied directly to concrete, such as liquid floor hardener, waterproofing,

dampproofing, membrane roofing, flooring, painting, and other coatings and finish materials, unless otherwise acceptable to Engineer.

3.11 CONSTRUCTION JOINTS

A. General: Construction joints shall conform to typical details and be located where shown on the Plans or where approved by the Engineer. Locate joints to minimize impairment to the strength of the structure.

B. Place construction joints perpendicular to the main reinforcement. Continue reinforcement across construction joints.

C. Walls: To assure a level and straight joint in exposed vertical surfaces, tack a 3/4 inch x 1-1/4 inch strip of dressed lumber to exposed face form at construction joint.

1. Place concrete 1 inch above underside of strip.

2. During stripping, carefully remove tack strip to prevent chipping or spalling.

3. Maximum spacing between vertical construction joints shall be 60 feet.

D. Provide keyways at least 1½-inches deep in construction joints in walls and slabs, unless shown otherwise. Bulkheads designed for this purpose may be used for slabs if approved by Architect.

3.12 CONTRACTION (CONTROL) JOINTS

A. Provide joints of size and at locations specified below:

1. In slab on grade, provide 1/8 inch wide by 1-1/4 inches deep joints at 20 feet maximum spacing in each direction, unless otherwise shown or noted.

2. Where joint pattern conforms to structural grid indicated on the drawings, joints shall occur on the centerline and midway between columns.

3. Construct contraction joints at right angles to the line of the wall.

4. Construct contraction joints directly opposite contraction joints in abutting concrete pavement or curb and gutter sections.

B. Sawcut as soon as concrete has hardened sufficiently to prevent aggregates being dislodged by saw. Complete sawcutting operations within 24 hours of the introduction of water to the mix.

1. Sawed joints shall be constructed by sawing a groove in the concrete with a 1/8-inch blade to the depth indicated.

2. Provide and ample supply of saw blades on the job before concrete placement is started.

3. Have at least 2 standby sawing units in good working order available at the jobsite at all times during the sawing operation.

C. Perform all cuts cleanly and smoothly to a constant and equal depth in as continuous an operation as possible to avoid misalignment of joints.

1. Use only experienced personnel.

2. Use forms or templates as required to achieve consistent lines.

3.13 ISOLATION JOINTS

A. Do not run reinforcement or other fixed metal items, embedded in or bonded to concrete, continuously through joint.

B. Finish slab edges along isolation joints neatly with a slightly rounded edging tool where exposed to view.

3.14 REPAIR OF DEFECTIVE WORK

A. Where concrete is under strength, out of line, level or plumb, or shows objectionable cracks, honeycombing, rock pockets, voids, spalling, exposed reinforcement, or is otherwise defective, and in the Engineers's judgment, these defects impair the proper strength or appearance of the work, the Engineer will require its removal and replacement at the Contractor's expense.

B. Immediately after stripping and before concrete is thoroughly dry, patch minor defects, form-tie holes, honeycombed areas with patches that match finish of adjacent surface.

1. Tie holes shall be filled solid with patching mortar.

2. Cut out honeycombed or otherwise defective areas to solid concrete to a depth of not less than 1 inch.

3. The edges of the cut shall be perpendicular to the surface of the concrete.

4. Saturate the area to be patched and at least 6 inches adjacent thereto with water before placing the mortar.

5. Mix the mortar approximately 1 hour before placing and remix occasionally during this period with a trowel without the addition of water.

6. A grout of cement and water mixed to the consistency of paint shall then be brushed on to the surfaces to which the mortar is to be bonded.

7. Compact the mortar into place and screed slightly higher than the surrounding surface.

8. Finish patches on exposed surfaces to match the adjoining surfaces, after they have set for an hour or more.

9. Cure patches as specified for the concrete.

C. The specified patching mortar may be used in lieu of the above method when color match of the adjacent concrete is not required. Prior approval by the Engineer is required.

D. All structural repairs shall be made with prior approval of the Engineer of Record, as to method and procedure, using the specified epoxy adhesive and/or epoxy mortar. Where epoxy injection procedures must be used, an approved low viscosity epoxy made by the manufacturers previously specified shall be used.

3.15 FIELD QUALITY CONTROL

A. Comply with requirements of Section 01 45 23 - Testing and Inspection Services.

B. The Owner's Testing Agency will:

1. Provide full time special inspection for concrete placement.

2. Inspect concrete placement for conformance with the Contract Documents in accordance with the California Building Code.

C. Sampling Fresh Concrete: Samples for strength tests shall be taken in accordance with ASTM C172. Cylinders and cores for acceptance shall be made, cured and tested in accordance with ASTM C31 and ASTM C39.

1. Slump: ASTM C 143; one test for each concrete load at point of discharge; and one test for each set of compressive strength test specimens.

2. Air Content: Air content tests shall be made each time compressive strength cylinders are taken of concrete required to be air entrained.

3. Compression Test Specimen: One set of 4 standard cylinders for each compressive strength test, unless otherwise directed. Mold and store cylinders for laboratory cured test specimens except when field-cure test specimens are required.

4. Compressive Strength Tests: One set for each 10 cubic yards or fraction thereof, of each concrete type and strength placed in any one day, 1 specimen tested at 7 days, 2 specimens tested at 28 days, and 1 specimen retained in reserve for later testing if required. Compressive strength tests are not required for exterior concrete paving.

5. When frequency of testing will provide less than 5 tests for a given type and strength of concrete, conduct testing from at least 5 randomly selected batches or from each batch if fewer than 5 are used.

6. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, evaluate current operations and provide corrective procedures for protecting and curing the in-place concrete.

7. Strength level of concrete will be considered satisfactory if averages of sets of two consecutive strength test results equal or exceed specified compressive strength, and no individual strength test result falls below specified 28 day compressive strength by more than 500 psi.

D. Structural Grout for Horizontal Joints: Verify that required mixing procedures are taken. One set of four samples will be taken for compression tests for each day grouting takes place. Observe initial grout placement and conduct periodic visual inspections of in-place work.

E. Additional Tests: The testing agency will make additional tests of in-place concrete when test results indicate specified concrete strengths and other characteristics have not been attained in the structure, as directed by Engineer.

1. Testing agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42, or by other methods as directed.

2. Owner shall back charge the Contractor for such tests conducted, and any other additional testing as may be required, when unacceptable concrete is verified.

3.16 BACKFILL

A. After curing, remove debris; backfill, grade and compact the area adjoining the concrete to conform to the surrounding area in accordance with lines and grades indicated.

3.17 CLEANING

A. Comply with requirements of Section 01 71 00 - Cleaning.

B. Protect completed concrete from damage until accepted.

C. Repair damaged concrete and clean concrete discolored during construction.

1. Concrete that is damaged shall be removed and reconstructed for the entire length between regularly scheduled joints.

2. Refinishing the damaged portion will not be acceptable.

3. Remove damaged portions and dispose of as directed.

D. Ensure removal of bituminous materials, form release agents, bond breakers, curing compounds or other materials employed in work of concreting which would otherwise prevent proper application of sealants, liquid waterproofing, or other delayed finishes or treatments.

E. Where cleaning is required, take care not to damage surrounding surfaces or leave residue from cleaning agents.

END OF SECTION