

SECTION 03370**SHOTCRETE****PART 1 – GENERAL**

1.1 SUMMARY

- A. Specialty Construction:
 - 1. Description: Shotcrete application, cutting, sculpting and finish work has been deemed as specialty construction work within the construction documents. All Contractor work related to the specialty construction shall be coordinated with Wally Hollyday Skateparks prior to the start of construction.

- B. Related Work:
 - 1. Section 03110: Concrete Formwork
 - 2. Section 03210: Concrete Reinforcement
 - 3. Section 03310: Cast-In-Place Concrete
 - 4. Section 03380: Concrete Curing

1.2 QUALITY ASSURANCE

- A. Standards: Comply with the requirements of the current edition of the following codes and standards, except as herein modified:
 - 1. IBC: "International Building Code", latest edition.
 - 2. American Concrete Institute (ACI): 506, Chapter 13, Wet Method. Chapter 5, Shotcrete Crew.
 - 3. ASTM: "American Society for Testing Materials"

- B. Shotcrete Contractor's Required Experience: (revised 5/07/13 per Addendum #1)
 - 1. The shotcrete specialty contractor shall show evidence of having adequate experience in constructing quality concrete skate parks. In order to be considered for this project, the skate park contractor must have self-performed shotcrete for at least five (5) public poured-in-place concrete skate parks within the last 4 years. The skate parks must be complete and currently in operation. The examples must include features similar in nature to the Ann Arbor project. Experience constructing skatepark bowls in excess of 9 foot deep with pool coping must be included in qualifying examples. The contractor must submit a list of qualifying projects with the name, address, and current telephone number of the Client's operator and Architect of Record. Pre-cast skatepark experience will not be considered as qualifying examples.

2. The city and its agents reserve the right to consider contractor's references and reputation in determining qualifications of specialty skate park contractor. Acceptance of qualifications to meet minimum specialty skate park contractor requirements will be determined solely at the discretion of the city with prior approval of the design consultant.
- C. Concrete Testing: (revised 5/07/13 per Addendum #1)
1. Prepare test specimens by each application crew using the equipment, materials and mix proportions proposed for the Project. The City of Ann Arbor Construction Administrator and /or testing company shall observe preparation of test panels noting placement of shotcrete by applications crew.
 2. ~~Test panel shall be at least 4 feet x 4 feet x 6 inch sample (not part of finished Project) with a 7'-0" radius, the same reinforcement as in the proposed structure and 2" round (HSS 2.375" x 0.154") steel coping. Provide one test panel on site for each specified type of concrete finish.~~ 18" x 18" x 6" shotcrete panels will be required for each shotcrete pour for lab testing. Cylinders will be required for all other concrete pours. A Testing shall take at least three (3) cores from the specimen and test them in accordance with the requirements of ASTM C42.
 3. Secure and protect Test Panels during construction and test for compliance with these Specifications.
- D. Test strength of the shotcrete as work progresses as follows:
1. Test concrete cylinders in accordance with ASTM C42. A set of three (3) cylinders shall be made not less than once each shift or no less than one for each 50 cubic yards of shotcrete placed through the nozzle. Cylinders shall be soaked in water for a minimum of 40 hours before testing.
 2. When the length of a cylinder is less than twice the diameter, apply the correction factors given in ASTM C42 to obtain the compressive strength of individual cylinders. The average compressive strength of three cylinders taken, representing a shift or 50 cubic yards of shotcrete, must equal or exceed 0.85f'c with no individual cylinder less than 0.75f'c.
- E. Shotcrete cylinders grade 2 required.
- F. Acceptance: Final acceptance of the shotcrete will be based upon the results obtained from testing of the specimen cylinders tested strictly in accordance with the provisions of ACI 506.2. A mean test cylinders grade of 2.5 or less is acceptable. Individual shotcrete test cylinders with a grade greater than 3 are unacceptable. Use of data obtained from impact devices will not be

permitted for final acceptance of the shotcrete. However, these data may be useful for determining uniformity of the shotcrete.

- G. Certification: Nozzleman certification shall be in accordance with ACI 506.3R

1.3 SUBMITTALS

- A. Design of Concrete Mixes: Submit two copies of design mix to the City of Ann Arbor Construction Administrator for approval:
 - 1. The Contractor shall be responsible for and pay for the design of all concrete mixes. Design of concrete mixes shall be performed by a Testing Laboratory selected by the Client. Design methods to be in accordance with ACI 318-71.
 - 2. Make three trial mixes using the proposed aggregate.
 - 3. Make advance tests of trial mixes with proposed materials. Test four cylinders in accordance with ASTM C-39 at 7 days and 28 days. Do not place concrete on the Project Site until laboratory reports and breaks of confirmation cylinders indicate that proposed mixes will develop required strength?
 - 4. Check mix design and revise, if necessary, wherever changes are made in aggregate or in surface water content of aggregate or workability of concrete. Slump shall be the minimum to produce a workable mix. Laboratory shall prescribe minimum water quantity.
 - 5. If Portland cement reducers or other additives are used, submit control mix design without reducers or additives as well as mix exactly proposed to be used.
- B. Manufacturer's Data: Current printed specifications with application and installation instruction for proprietary materials including concrete admixtures.
- C. Pour Schedule: The Contractor to submit schedule of locations to be shot within a day's work and sequence of work for review by the Client.
- D. Shop Drawings: Radial templates cut to exact radii shown on drawings to ensure exact radii from flat bottom of bank/embankment to face of coping. Template shall be fabricated from steel or 3/4" Plywood.
- E. Concrete Samples: Representative samples of materials for materials testing, mix proportion testing, and finish. Provide on site, minimum (1) 4'-0" x 4'-0" x 6" sample (not part of finished Project) of shotcrete with a 3'-0" radius and the same reinforcement as in the proposed structure for finish inspection and approval.

1.4 DELIVERY, HANDLING, AND STORAGE

- A. Properly deliver and handle materials to prevent contamination, segregation or damage to materials.

- B. Store cement in weather tight enclosures raised above grade to protect against dampness and contamination.
- C. Prevent segregation and contamination of aggregates by proper arrangement and use of stockpiles.
- D. Store admixtures in accordance with the manufacturer's recommendation to prevent contamination, evaporation, or other damage.

1.5 REFERENCE STANDARDS:

- A. ACI 211.1 - Recommended Practice for Selecting Proportions for Normal-Weight Concrete.
- B. ACI 211.3 - Recommended Practice for Selecting Proportions for Lightweight Concrete.
- C. ACI 301- Specifications for Structural Concrete for Buildings.
- D. ACI 305 - Recommended Practice for Hot Weather Concreting.
- E. ACI 306 - Recommended Practice for Cold Weather Concreting.
- F. ACI 318 - Building Code Requirements for Reinforced Concrete.
- G. ASTM C33 - Concrete Aggregates.
- H. ASTM C94 - Ready-Mixed Concrete.
- I. ASTM C143 - Test for Slump of Portland Cement Concrete.
- J. ASTM C150 - Portland Cement.
- K. ASTM C260 - Air-Entraining Admixtures for Concrete.
- L. ASTM C494 - Chemical Admixtures for Concrete.
- M. ASTM C618 - Fly Ash and Raw or Calcined Natural Pozzolans for Use in Portland cement concrete.

1.6 JOB CONDITIONS:

- A. Environmental Conditions: Submit written plan to City of Ann Arbor indicating methods used to monitor wind velocity, relative humidity, temperature, and concrete temperature in order to maintain specified maximum rate of evaporation.
- B. Coordination:

1. Coordinate schedules of concrete work to allow adequate time for installation of other related work.
2. Contractor to ensure that anchor bolts and other embedded steel items to be cast into concrete are accurately placed in accordance with the plans.
3. Contractor to ensure that the mechanical and electrical equipment pads are constructed in accordance with the manufacturers requirements.
4. Contractor to ensure that all footings are placed on well compacted and leveled grade in accordance with the soils report and its recommendations.
5. Contractor to ensure that all formwork is installed with sufficient supports to prevent sagging and misalignment.
6. Contractor to provide a power floated finish to all floors that allows for smooth drainage without depressions that could hold water. All slopes to drains are to be constructed as laid out on the plans.

PART 2 – PRODUCTS

2.1 MATERIALS:

- A. Portland Cement: ASTM C150, Type I or II.
- B. Fly Ash: ASTM C618.
- C. Fine Aggregate: Clean, hard, durable, uncoated natural sand, free from silt, loam or clay, meeting requirements of ASTM C-33.
- D. Coarse Aggregate: Class II-Hard durable, un-coated crushed limestone meeting requirements of ASTM C-33. Unless otherwise noted in aggregate size 3/8" maximum, No. 5, 56 or 57.
- E. Water: Fresh, clean, potable, and free of deleterious acids, mixing, and curing water, as available from the City of Ann Arbor.
- F. Admixtures: Use only accepted admixtures meeting the following requirements:
 1. Chemical Admixtures: ASTM C494.
 2. Water reducing, retarding or accelerating admixtures shall conform to ASTM C.
 3. Air-entraining Admixtures: ASTM C1141. Air entrainment prior to shooting shall be no greater than 1.5% - 3%.
 4. The use of Calcium Chloride shall not be permitted. The Contractor shall submit details of proposed admixtures with the concrete mix design.

2.2 PROPORTIONS AND MIXING:

- A. Proportions and design in accordance with approved mix design.
1. Portland Cement: 600 pounds minimum per 27 cubic foot design.
 2. Fly Ash: Maximum 20% by weight of the combined total weight of the cement and fly ash.
 3. 28-Day Compression Strength: 4000 p.s.i. Selected mix proportions on the basis of compressive strength tests of specimens shall be cut from the concrete test panels not earlier than 5 days after concrete placement. For mix acceptance purposes, average core strengths shall be least equal to $f'c$ for cores with L/D of 2.0. For cores with L/D between 1.0 and 2.0, use correction factors given in ASTM C42.
 4. Slump: 2" maximum.
 5. Admixture: No admixtures without approval. Introduce admixtures in quantities and according to methods recommended by admixture manufacturer. Add air-entraining agent to concrete as scheduled.
 6. Mixing: Ready mixed concrete in accordance with ASTM C-94. Do not transport or use concrete after 1-1/2 hours have elapsed from time of initial mixing. Supplier of transit-mixed concrete shall have a plant of sufficient capacity, and adequate transportation facilities to assure continuous delivery at required rate, to provide continuous concrete placement throughout a pour.
 7. Grout and Dry Pack: Non-Shrink, Non-Metallic: U.S. Grout Corp. "Five Star Grout" ASTM C-877, C-191, and C-109, 5,000 PSI.
 8. Test Data: Submit for acceptance proportioning and test data from prior experience if available. If data from prior experience are not available or accepted, make and have tested specimens from three or more different mix proportions in accordance with pre-construction testing requirements of this Specification.
 9. Review: Mix design shall be reviewed for acceptance by the City of Ann Arbor Construction Administrator and/or the approved testing company.

2.3 CONCRETE APPLICATION EQUIPMENT

- A. For Wet Mix Shotcrete:
1. Mixing Equipment: Capable of thoroughly mixing aggregate, cement and water in sufficient quantity to maintain continuous placement.
 2. Ready-mixed Concrete: ASTM C94, except that it may be delivered to the site in the dry state if the equipment is capable of adding the water and mixing it satisfactorily with the dry ingredients.
 3. Air Supply: Clean air adequate for maintaining sufficient nozzle velocity for parts of work, and for simultaneous operation of blow pipe for cleaning away rebound.
 4. Delivery Equipment: Capable of discharging aggregate-cement-water mixture accurately, uniformly, and continuously through delivery hose.

PART 3 – EXECUTION**3.1 INSPECTION**

- A. Examination: Examine concrete formwork and verify that it is true to line and dimension, adequately braced against vibration, and constructed to permit escape of air and rebound but to prevent leakage during shotcreting. Correct deficiencies.
- B. Inspection: Inspect reinforcement steel and items to be embedded in concrete. Correct any deviations from the accepted shop drawings.
- C. Notification: Notify other trades involved in ample time to permit the proper installation of their work. Contractor to coordinate with all trades and their respective work for a smooth project.
- D. Existing Surfaces: Examine existing concrete surfaces for unsound material. Correct deficiencies.

3.2 PREPARATION FOR INSTALLATION OF CONCRETE

- A. Forms: Use a form-coating material on removable forms to prevent absorption of moisture and to prevent absorption of moisture and to prevent bond with shotcrete.

3.3 CONCRETE BATCHING AND MIXING

- A. Proportions: Mix proportions shall be controlled by weight batching. The Contractor's Testing Laboratory shall maintain quality control records during shotcrete production and make those records available to the Client.
- B. Scheduling: Concrete shall be placed within 90 minutes of batching and shall not be placed when the temperature exceeds 90°F [32°C] unless pre-approved by the City of Ann Arbor Construction Administrator.

3.4 CONCRETE PLACEMENT

- A. Placement: Use suitable delivery equipment and procedures that will result in shotcrete in place meeting the requirements of this Specification. Determine operating procedures for placement in, extended distances, and around any obstructions where placement velocities and mix consistency must be adjusted.
- B. Placement Techniques: Do not place shotcrete if drying or stiffening of the mix takes place at any time prior to delivery to the nozzle.
 - 1. Control thickness, method of support, air pressure, and/or water content of shotcrete to preclude sagging or sloughing off. Discontinue

- shotcreting or provide suitable means to screen the nozzle stream if wind or air currents cause separation of the nozzle stream during placement.
2. Hold nozzle as perpendicular to surface as work will permit, to secure maximum compaction with minimum rebound.
 3. In shotcreting walls, begin application at bottom. Ensure work does not sag.
 4. Layering:
 - a. Build up layers by making several passes of nozzle over work area.
 - b. Broom or scarify the surface of freshly placed shotcrete to which, after hardening, additional layers of shotcrete are to be bonded. Dampen surface just prior to application of succeeding layers.
 - c. Allow each layer of shotcrete to take initial set before applying succeeding layers.
 - d. Use radial templates to insure exact radii from flat bottom of bank/embankment to face of coping. Template shall be fabricated from steel or 3/4" Plywood. Check every horizontal foot when applying shotcrete for conformance of intended wall radii. Brace template and place levels at arc to tangent connections to insure no kinks will be formed. Kinks at the bottom of bowls will not be accepted. Slumping of the shotcrete causing coping setback will not be accepted.
 - e. Remove any rebound or accumulated loose aggregate from surfaces to be covered prior to placing the initial or any succeeding layers of shotcrete.
 5. Placement Around Reinforcement:
 - a. Hold the nozzle at such distance and angle to place shotcrete behind the reinforcement before any material is allowed to accumulate on its face. In the dry-mix process, additional water may be added to the mix when encasing reinforcement to facilitate a smooth flow of material behind the reinforcement.
 - b. Test to ascertain if any void or sand pockets have developed around or behind reinforcement by probing with an awl or other pointed tool after the shotcrete has achieved its initial set, by removal of randomly selected bars, or coring or other suitable methods.
- C. Access: Allow easy access to shotcrete surfaces for screening and finishing, permitting uninterrupted application.

3.5 REMOVAL OF SURFACE DEFECTS IN CONCRETE

- A. General: Remove and replace shotcrete which lacks uniformity, exhibits segregation honeycombing, or lamination, or which contains any dry patches, slugs, voids, or pockets. Remove and replace defective areas/panels of shotcrete.

- B. Sounding: Sound work with hammer for voids. Remove and replace damaged in-place shotcrete.

3.6 CONCRETE FINISH

- A. Finish-General: Smooth form finish shall consist of a smooth, hard, uniform texture with a minimum of seams.
- B. Radial/Banked Wall Finish: Float finish on radial/banked face of wall shall consist of a smooth, hard, uniform surface of smooth steel trowel. Level to a tolerance of ¼ inch in 10 feet when tested with a 10 foot [3.05m] steel straightedge placed on the surface horizontally and vertically with radial/bank template with the appropriate radii/angle. Grinding the surfaces will not be an acceptable means of achieving the intended radii/angle. Concrete finish work shall match the approved sample poured on site.

3.7 CONCRETE JOINTS

- A. Cleaning: The entire joint shall be thoroughly cleaned and wetted prior to the application of additional shotcrete.
- B. Reinforcement: Make joints perpendicular to the main reinforcement. Continue reinforcement across joints.

3.8 CRACKING

- A. Cracking from inadequate curing is not allowed. Sawcut joints and construction joints are shown in the construction drawings. The Contractor may, with approval of the Construction Administrator, recommend and detail other joints required to prevent cracking.
- B. The Contractor shall repair all cracks and displacements larger than 1/16".

END OF SECTION 03370