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Permeable/Open-Cell Lightweight Cellular Concrete (P-LCC)

Geotechnical aspects of the specification were prepared by Langan Engineering and Environmental Services, Inc.

1. GENERAL
   1. DESCRIPTION
      1. Work Included: This work shall consist of batching, mixing, placing and testing P‑LCC of the appropriate density as indicated by the specifications. A trained P-LCC installer shall furnish labor, material, equipment, and supervision for the installation of the P-LCC in accordance with the drawings and specifications.
   2. QUALITY ASSURANCE
      1. Use skilled labor that is thoroughly trained, experienced, and familiar with the specified requirements and the methods for proper performance of this work.
      2. The P-LCC installer shall be approved in writing by Owner.
   3. SUBMITTALS
      1. The prime contractor shall list the product and qualified installer of the P-LCC and shall not employ any product or producer without the prior approval of the geotechnical engineer of record (GEOR).
      2. Product data: within 30 calendar days after award of the contract, the prime contractor shall submit a mix design for approval by the GEOR and civil engineer of record (CEOR)
         1. Manufacturer’s specifications, catalog cut sheet, and other engineering data needed to demonstrate to the issuing authority compliance with the specified requirements.
      3. Mix Design: Submit a mix design that will produce a cast density that complies with those listed in Section 2.2.1 of this specification at point of placement and a compressive strength within the range listed in Section 2.2.1. Include laboratory data using the mix design verifying un-foamed density, final foamed density, permeability (cm/sec) and compressive strengths. Mix design shall include water/cementitious ratio and foam solution dilution ratio, in accordance with manufacturer’s recommendations. The mix design should also include Field Permeability Check Testing, by testing the percolation rate in modified 6” x 12” cylinder molds, filled half-way. The mix design should also include field saturation testing by the special inspector.
      4. Work Plan: Submit a work plan before placement of P-LCC material. The plan shall include:
         1. Proposed construction sequence and schedule
         2. Type of equipment and tools to be used.
         3. Material list of items and manufacturer's specifications
         4. P-LCC lift thickness
         5. P-LCC cure time and minimum strength prior to placing the next lift
         6. QA/QC and testing items and protocols frequency.

1. PRODUCTS
   1. MATERIALS
      1. Foaming Agent: A foaming agent shall be used and shall comply with the standard specifications of ASTM C 869 when tested in accordance with ASTM C 796. Admixtures shall be tested by the foam concentrate manufacturer for compatibility with the foaming agent.
      2. Cement: the Portland cement shall comply with ASTM C 150. Other supplemental cementitious material such as fly ash may be used when approved by the project engineer. Supplementary cementitious materials shall be tested prior to the start of the project for compatibility with the foaming agent.
      3. Admixtures: admixtures for accelerating, water reducing, and other specific properties may be used when specifically approved by the GEOR. Admixtures shall be tested in mix design prior to the start of the project for compatibility with the foaming agent.
      4. Water: use water that is potable and free from deleterious amounts of alkali, acid, and organic materials, which would adversely affect the setting or strength of the P-LCC.
      5. Filter Fabric: Shall have permeability equal to or greater than that of the P-LCC. Filter fabric shall also have a maximum apparent opening size (AOS, ASTM D4751) of 0.212 mm (U.S. sieve size 70).
   2. PROPERTIES
      1. Two types of P-LCC are to be supplied for the project: (1) general P-LCC to be applied across the site at multiple depths and (2) high density P-LCC to be cast only in the upper two feet of the LCC section. P-LCC shall meet the following properties:

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| **General P-LCC** | | | |
|  | Target | Maximum | Minimum |
| General Cast Density, pcf (ASTM C 796) | 26 | 28 | 24 |
| Compressive Strength at 28 Days, psi  (ASTM C 495) | NA | 200 | 50 |
| Coefficient of Permeability, cm/sec  (ASTM D 2434 – modified) | 0.1 (1E-1) | NA | 0.005 (5E-3) |
| Saturated Density, pcf | 55 | 68 | 50 |

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| **High Density P-LCC – to be cast only within upper two feet of overall P-LCC section** | | | |
|  | Target | Maximum | Minimum |
| Cast Density of LCC, pcf  (ASTM C 796) | 30 | 32 | 28 |
| Compressive Strength at 28 Days, psi  (ASTM C 495) | NA | 200 | 80 |
| Coefficient of Permeability, cm/sec  (ASTM D 2434 – modified) | 0.1 (1E-1) | NA | NA |
| Saturated Density, pcf | 55 | 68 | 50 |

1. EXECUTION
   1. Subgrade: Subgrade to receive P-LCC material shall be free of all loose and extraneous material. Subgrade shall be uniformly moist, and any excess water standing on the surface shall be removed. The subgrade shall be approved by the GEOR before placing

P-LCC material.

* 1. Curing: A minimum 12-hour curing period between lifts is required. Backfill or other usual loadings, including additional lifts of P-LCC, on the P-LCC shall not be permitted until the P- LCC has attained a compressive strength of at least 5 psi.
  2. Weather Conditions: If ambient temperatures are anticipated to be below 40 degrees F within 24 hours after placement, the mixing water shall be heated when approved by the manufacturer of the foaming agent or placement shall be prohibited. Placement shall not be allowed on frozen ground.
  3. Batching and Mixing: Cellular concrete shall be job site batched, mixed with the foaming agent and placed with specialized equipment certified by the manufacturer of the cellular concrete lightweight material. Cement and water may be premixed and delivered to the job site and the foaming agent added on site. Dilution ratio shall be adjusted as needed per manufacture’s recommendation to achieve required end product.
  4. Placement:
     1. Place P-LCC in lifts not to exceed 36 inches in thickness, unless otherwise recommended by the P-LCC manufacturer and approved by the GEOR.
     2. After curing for minimum of 12 hours, any crumbling area on the surface shall be removed before the next layer is placed. Surface stepping to achieve grade and super elevation shall not be less than 6 inches in thickness. Grades of up to 5 percent may be made by adding a thickening agent to the mix in conformance with the manufacturer's recommendation.
     3. Subgrade and P-LCC should be protected from water inundation until the P-LCC is sufficiently cured and has sufficient overlying weight so it does not become buoyant.
     4. Freshly placed P-LCC should be protected from rain until it has been sufficiently cured to prevent damage.
     5. Freshly placed P-LCC should be cured at least 3 hours before exposed to vibrations higher than a peak particle velocity 0.05 inches per second – such as those that may be generated during ground improvement activities.
  5. Handling: Avoid excess handling of P-LCC according to industry standards.
  6. Filter Fabric: Use filter fabric between P-LCC and adjacent soil and between P-LCC and shoring, where shoring will be removed after P-LCC placement.

1. QUALITY CONTROL TESTING BY CONTRACTOR AND OWNER
   1. DENSITY CONTROL
      1. During placement of the initial batches, check the un-foamed and foamed densities for each 100 cubic yards of P-LCC or as recommended per the GEOR and adjust the mix as required to obtain the specified cast density at the point of placement per ASTM.
      2. Field saturated density test procedures developed and prepared by the special inspector shall be performed on one sample for each 100 cubic yards of P-LCC or as recommended per the GEOR. GEOR to review and approve test procedures prior to commencement of work.
   2. COMPRESSIVE STRENGTH: The compressive strength shall be tested under ASTM C 495 except as follows:
      1. Four (4) specimens (one 7-day and three 28-days) shall be taken for each 100 cubic yards of P-LCC or as recommended per the GEOR. Unless otherwise approved, the specimens shall be 3 x 6 inch cylinders. During molding, place the LCC in 2 equal layers and raise and drop the cylinders 1 inch, 3 times on a hard surface or lightly tap the side or bottom of the cylinder to close any accidental entrained air. No rodding is allowed.
      2. Specimens must be covered and protected immediately after casting to prevent damage and loss of moisture. Specimens shall be moist cured in the molds for 7 days and air dry a minimum of 24 hours and minimum of 72 hours before the 7-day and 28- day compressive strength testing, respectively. Specimens shall not be oven dried.
      3. Contractor should maintain process control “run” charts of un-foamed and foamed density, field percolation result, and compressive strength data, updated daily for review by Owner’s representative, and distributed weekly to applicable project team members.
   3. PERMEABILITY:
      1. Proof of permeability (per ASTM D 2434 – Modified) of the proposed P-LCC mix design shall be provided in the mix design submittal. If there is any change to the mix design during production, additional permeability testing will be required. Two samples per week should be cast per ASTM D 2434 and shipped to Castle Rock Consulting for testing.
      2. Field falling head permeability per procedures prepared by the special inspector performed on two samples per day. Falling Head permeability test procedures to be reviewed and approved by GEOR prior to commencement of work.
   4. MOCK UP TEST SECTION: One mock up test section shall be installed prior to construction to prove out the contractor’s construction methods.
   5. Side-by-side sampling and testing by QC and QA staff should occur once daily during the LCC placement on the Pilot Project to identify any issues. At least one set of permeability samples should also be taken for saturation and drain down density and a permeability verification.
   6. UNFOAMED SLURRY TESTING: Test unfoamed slurry density periodically during foaming to verify actual density (PCF) is +/- 1.5% of target. Target to be established in mix submittal.
   7. QUALITY ASSURANCE INSPECTIONS & ACCEPTANCE TESTING BY OWNER’S AGENCY
      1. Owner shall employ a qualified Special Inspector to observe LCC placement and test LCC as described below.
      2. Daily Inspections should include review of previous day’s density testing of un- foamed and foamed test data, field percolation test results, any 7-day & 28-day compressive strength data, and location of samples taken. Initially use mix design for 7-day to 28-day strength correlation, switching to project data when three sets are available to predict 28-day strengths.
      3. Perform one side-by-side comparison test with Contractor every 1000 cubic yards, and verify saturation & drain-down densities and permeability (per ASTM D 2434) values every 1000 cubic yards placed, or whenever the field percolation rates are more than 20% lower than the mix design values.