5 - STABILIZED EARTH SPECIFICATIONS

SUMMARY - This Section specifies cement-stabilized rammed earth, including formwork, reinforcing, mix design, placement procedures, and quality control measures.

Stabilized Rammed Earth (SRE): Selected mineral soils and aggregates containing natural clay binders and well-graded aggregates blended with manufactured binders (e.g. cement), brought to optimum moisture levels, then pneumatically compacted in layers within a fully enclosed and well-braced form.

5.1 QUALITY ASSURANCE

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Installer Qualifications: The contractor or supervising consultant shall have a minimum of five years experience and journeymen shall have a minimum of three years of experience in the mixing, forming, placement and compaction of SRE. Additionally, the contractor must be able to demonstrate competency in a project of similar scope and scale.

Crew size: The contractor shall provide sufficient personnel to complete the work in a continuous and controlled manner in order to maintain consistency in moisture content and rates of compaction, thereby minimizing cold joints.

Performance: In accordance with ACI 506, the ultimate measure of quality shall be based on the performance of actual construction. The quality of SRE construction is primarily achieved through the skill, care, and experience of the installers. The installers shall have the responsibility and flexibility to adjust field conditions as needed to insure that the final construction will perform structurally as designed. The primary measure of structural performance will be design strength in compression.

Strength: See structural calculations for minimum compressive strength for individual projects. Averages and curves shall not be used.

5.1.2 TESTING

Pre-Construction Testing: In the absence of previous data using the same mix designs, installer, and equipment: pre-construction testing shall be required. Where pre-construction testing is to be waived, submit justification that includes mix design and test results from other projects that have used the exact same mix design. Pre-construction testing may include (but is not limited to) maximum dry density, compressive strength, total water absorption, and linear drying shrinkage.

Testing during Installation: Random periodic inspections may be conducted by the county building inspector, special inspector, or project engineer to observe mixing and placement of stabilized rammed earth and the construction of test samples to verify installed SRE conforms to expectations.

5.1.3 PROJECT CONDITIONS

Cold Weather Installation: Protect SRE from physical or cosmetic damage or reduced strength caused by frost, freezing, or low temperatures. Discontinue work when ambient temperature is below 40 degrees Fahrenheit.

Hot Weather Installation: Above 100 degrees Fahrenheit, maintain constant moisture in prepared mixes to +/-1.5% of optimum, dampen adjacent surfaces before placing fresh mix, and protect all exposed surfaces of compacted material from rapid drying with appropriate coverings or misting devices.

Wet Weather Installation: Work shall not be allowed during conditions in which rainfall is affecting the ability of the workmen to maintain consistency of moisture content in the mix either prior to or during placement.
5.2 PRODUCTS

5.2.1 FORMING MATERIALS
Forms for Exposed SRE: Form surfaces shall be comprised of solid surfaced timbers, laminated beams, or plywood joined in sections to provide continuous, straight, smooth exposed surfaces.
Forming materials shall be selected to provide the largest practicable continuous surfaces free of joints.
Consult with project architect regarding location of form panel seams prior to formwork construction. Provide shop drawings if required.

5.2.2 REINFORCING MATERIALS
Reinforcing Bars: ASTM A 615, Grade 40, deformed, except as noted on the structural drawings.
Steel Wire: ASTM A 82, plain, cold-drawn steel.
Supports for Reinforcement: Bolsters, chairs, spacers and other devices for spacing, supporting and fastening reinforcing bars and welded wire fabric in place. Use wire bar type supports complying with CRSI specifications.

5.2.3 STABILIZED EARTH MATERIALS
Mineral Soils: Free from organic matter with no more than 2% by weight of organic or deleterious materials. Plasticity index shall not exceed 10.
Gradation: Maximum 30% passing 200 mesh sieve. ACI 506, 2.4 Table 2.1, gradation 1 or 2.
Maximum Clay Content: 20%
Maximum aggregate size: 3/4 inch
Cement: ASTM C150 compliant Portland Type I, Portland Type II, Portland Type III, or block cement.
Water: Water used for hydration of SRE shall be potable water.
Water used for pre-wetting and curing shall be free from substances that could cause staining or adversely affect the appearance of finished products.

5.2.4 STABILIZED RAMMED EARTH EQUIPMENT
Mixing Equipment: Capable of accurately proportioning and thoroughly mixing SRE materials in sufficient quantities to maintain continuous placement. Mixing equipment should be capable of eliminating agglomerations greater than 1/2” in diameter. Ground mixing shall not be permitted unless crew is able to demonstrate sufficient control over moisture, proportioning, and uniformity.
Delivery System: Capable of delivering prepared mix to the form work in a timely manner and at sufficient rates to supply work force with uninterrupted material delivery for one complete and continuous lift.
Compacting Equipment: Sufficient pneumatically powered tools and air compression equipment to achieve compaction levels specified by the project engineer and/or determined through pre-construction testing.
5.3 EXECUTION

5.3.1 FORMWORK
Design forming system and erect form panels such that horizontal lengths of wall shall be continuous for each designated section. Form system shall be capable of maintaining accurate vertical lines per the project architect’s plan to the full desired height of the wall. Butt vertical and horizontal joints so as to result in visible seam marks of 1/8” or smaller.
All formwork is to be adequately braced to prevent deflection greater than 3/8” over ten feet.
Form Preparation and Coatings: All forms are to be cleaned and treated with oil or water-based form release prior to each use. Form release agents shall not stain nor adversely affect SRE surfaces and shall not impair subsequent surface treatments.

5.3.2 REINFORCING
Vertical Reinforcing shall be in place prior to placement of first lift. Accurately position, support, and secure reinforcement against displacement. Maintain minimum 3” of spacing between reinforcing and faces exposed to weather.
Horizontal Reinforcing shall be set in place at the designated spacing as the wall rises in height. Marks on vertical reinforcing shall be used to identify locations for placement of horizontal reinforcing. Alternatively, all horizontal reinforcing may be set in place prior to compaction.
Cleaning: Before placing, clean bars free from rust, scale, dirt, grease, or other foreign substances which are, in the architect’s/engineer’s opinion, detrimental to the bond. After placing, maintain bars in a clean condition until completely embedded.

5.3.3 MIXING
Proportion mix ingredients in compliance with approved mix designs. Add water after blending dry ingredients to obtain desired moisture content. Maintain moisture content until mix is fully compacted or consolidated within the formwork.

5.3.4 COMPACTION
SRE mix shall be placed into forms in lifts of four to ten inches and compacted with pneumatic backfill tampers to a minimum of 90% compaction (relative to maximum compaction as determined by pre-construction testing following ASTM D 1557). Pneumatic ramming shall begin no later than fifteen minutes after mix has been placed and shall continue uninterrupted until satisfactory compaction is achieved.
Placement and compaction (ramming) shall be continuous and without interruption from one end of the formwork to the other. The foreman of the ramming crew shall at all times be present to verify the thoroughness of the compaction.
Placement of subsequent lifts shall begin as soon as practical upon completion of prior lift. If such time has elapsed that the top of the prior lift has begun to show signs of drying, the wall shall be dampened slightly to insure a uniform bond between layers. If required, clean the top of prior lift of loose material, roughen the top of the prior lift slightly and moisten prior to placement of fresh mix.
Upon completion of final lift, screed the wall top to be level and true with the required outward slope indicated on the project architect’s drawings. Compact by hand to achieve desired density and additional surfacing. Do not add excessive water to the wall top.
5.3 EXECUTION (Continued)

5.3.5 FIELD QUALITY CONTROL

Test Specimens: At the start of construction and until authorized to reduce testing by the project testing agency, for each day’s work one test block will be made having dimensions of approximately 18” x 18” x 8”. From each test block, the testing agency will obtain four test specimens. Production of test blocks shall mirror procedures for construction of in-situ walls. Test each of the specimens for compressive strength according to ASTM C 1140 and construction testing requirements in ACI 506.2.

Upon notice from testing agency, the required daily test specimens shall be reduced to four 3” x 6” test cylinders.

Strength test samples at 7, 14, and 56 days or as specified by project engineer.

Strength shall be determined in accordance with ASTM C39. Compressive strength shall comply with project engineer’s specifications.

Stabilized earth shall be considered to have reached 95% of its ultimate strength after 56 days.

5.3.6 STRIPPING AND CURING

Formwork shall be left in place and undisturbed for a minimum of 24 hours after completion.

Upon removal of forms, work shall be either kept moist for a period of 7 days with periodic applications of water, covered with plastic sheeting or burlap, or they may be cured with the application of an approved curing compound which can be shown to not stain or alter the appearance of the finished wall.