SAMPLE MATERIAL SPECIFICATIONS

The following paragraphs provide general guidelines on developing construction and material specifications for specific projects. Generally, the owner would hire services of a designer to perform a project-specific design.

The general guidelines given below should be modified to incorporate specific StoneTerra facing unit criteria and special project-specific requirements and to provide consistency with construction drawings. Any unnecessary requirements given below may be deleted depending upon project details.

The physical and mechanical properties of StoneTerra facing units and geogrid reinforcement properties are important in providing satisfactory long-term performance of the StoneTerra MSE wall systems.

The AIA A201-87, CSI 3-Part Format and CSI Page Format were utilized to provide the general conditions and formats.

PART 1: GENERAL

I. Summary Description

A. This section includes StoneTerra MSE retaining wall systems consisting of geosynthetic reinforcement (high tensile strength polymeric sheet materials called geogrids) placed between two horizontal layers of StoneTerra segmental concrete facing units and unifying compacted soil backfill. Work shall consist of furnishing all materials, labor, equipment, field supervision, and installing a StoneTerra MSE wall system in accordance with given specifications. All installations should conform to project drawings provided by the Owner or the Owner's Engineer.

B. Related Sections
   1. Section _____- Site Preparation
   2. Section _____- Earthwork

II. Reference Standards

A. Any reference standards that are not applicable to the project should be deleted. If there is a conflict between the given specifications and reference standards, the Owner's Engineer should make the final determination of applicable documents.

B. American Association of State Highway and Transportation Officials (AASHTO)
   1. LRFD Design Specifications, SI Units, 1st Edition, 2007
   2 Task Force 27 Report, In-situ Soil Improvement Techniques, Design Guidelines for Use of Extensible Reinforcements for Mechanically Stabilized Earth Walls in Permanent Applications, 1990
   3. Standard Specifications for Transportation Materials and Methods of Sampling and Testing, 1986

C. American Society for Testing and Materials (ASTM)
   1. ASTM D 422 – Standard Test Method for Gradation of soils
   2. ASTM D 424 – Standard Test Method for Determination of Atterberg Limits of Soils
   3. ASTM DG51 – Standard Test Method for Determination of Soil pH
   4. ASTM D698, D1997 – Standard Specification for Moisture Density Relationship for Soils, Standard Proctor and Modified Proctor Methods
   5. ASTM C33-99 - Standard Specification for Concrete Aggregates
   6. ASTM D3034 – Standard Specification for Polyvinyl Chloride (PVC) Plastic Pipe
   7. ASTM D1248 – Standard Specification for Corrugated Plastic Pipe
   8. ASTM C150 – Use of Cement in Concrete Blocks
   9. ASTM C260 – Use of Admixtures in Concrete
   10. ASTM C494 – Use of Admixtures in Concrete
   11. ASTM C805 – Schmidt Hammer Test for the determination of Compressive Strength of Concrete

D. Geosynthetic Research Institute (GRI)
   1. GRI GG1-87 - Standard of Practice for Geogrid Rib Tensile Strength
   2. GRI GG2-87 - Standard of Practice for Geogrid Junction Strength
   3. GRI GG5-87 – Standard of Practice for Geogrid Pullout
   4. GRI GS-6-88 – Standard of Practice for Interface Friction Determination by Direct Shear
   5. GRI GG4A-91- Determination of Long-Term Design Strength of Stiff Geogrids
   6. GRI GG4B-91- Determination of Long-Term Design Strength of Flexible Geogrids
   7. GRI GT7-92 - Determination of Long-Term Design Strength of Geotextiles
   8. GRI GG-3A &B-91 - Tension Creep Testing of Stiff & Flexible Geogrids
   9. GRI GT5-92 - Standard of Practice for Tension Creep Testing of Geotextiles

E. National Concrete Masonry Association (NCMA)
   1. TEK 2-4A - Specification for Segmental Retaining Wall Units

F. StoneTerra, Inc.
   1. Design Manual for StoneTerra MSE Wall Systems, December 2010

III. Definitions

A. StoneTerra Unit – A segmental concrete unit with shear keys made of a specified concrete mix design.

B. Gravity Soil Mass - Compacted structural fill placed immediately behind the wall, which contributes to the gravity mass of the wall structure.

C. Drainage Fill - Free-draining, well-graded, coarse-grained aggregates placed immediately behind the blocks to relieve hydrostatic pressures or seepage forces and to prevent clogging of aggregate drainage medium if a geotextile fabric is not used.

D. Retained Soil - Native soils or compacted structural fill situated immediately behind drainage fill. The primary function of the gravity wall is to retain this soil mass without failure.

E. Leveling Pad / Wall Foundation **-** Densely compacted and free draining crushed rock pad for distributing the weight of block wall over a wider area and for providing a working surface during construction.

F. Foundation Subgrade - Competent native soil subgrade or compacted structural fill subgrade for supporting the block wall structure as approved by a qualified geotechnical engineer.

G. Drainage / Discharge Pipe **-** Perforated pipe with adequate flow capacity placed at the rear base of the wall to discharge collected water into a suitable receptacle by gravity flow. Location of discharge pipe behind the wall depends upon the drainage requirements of the wall structure and the design of drainage system.

H. Drainage Swale **-** A small depression adjacent to the top of the wall to collect surface water run-off and discharge by gravity flow.

I. Geotextile filter – A filter fabric (with adequate permittivity or porosity) placed against the retained soil mass or between drainage media and retained soil mass to minimize clogging of drainage media.

J. Backslope **-** Retained soil slope behind the wall. Slope inclination, , is measured counterclockwise from the horizontal plane.

K. Foreslope / Toeslope **-** Downslope in front of the toe of wall.

L. Reinforced Backfill – Compacted structural fill placed behind the Drainage Fill or directly behind the StoneTerra™ units as outlined on the plans.

M. GeoSynthetic Reinforcement – High tensile strength polymeric sheet materials called geogrids or geotextiles manufactured for soil reinforcement purposes.

N. Geogrid Ultimate Tensile Strength – Breaking tensile strength when tested in accordance with GRI-GG1, as modified by AASHTO Standard Specification for Highway Bridges 1999 Interim, using a single rib having the greater of 3 junctions or 8 inches and tested at a strain rate of 10 percent per minute based on this gauge length. Values shown are minimum average roll values.

O. Geogrid Junction Strength – Breaking tensile strength of junctions when tested in accordance with GRI-GG2, as modified by AASHTO Standard Specification for Highway Bridges, 1999 Interim, using a single rib having the greater of 3 junctions or 8 inches and tested at a strain rate of 10 percent per minute based on this gauge length. Values shown are minimum average roll values.

P. Geogrid Long-Term Design Strength – The maximum allowable stress level of the polymeric grid used in the internal stability design calculations of the retaining wall. Ultimate Tensile Strength reduced by the effects of installation damage and durability.

Q. Geogrid Long-Term Allowable Design Strength – Long-Term Design Strength reduced by the Factor of Safety for design uncertainties.

IV. System Description

A. Design Requirements - Design the retaining wall system in accordance with the design guidelines presented in the StoneTerra MSE Wall Design Manual, December 2010 provided by StoneTerra, Inc. Engage and pay for the services of a Designer to design and develop Design Data for the retaining wall system. Use of Ultrawall Software™ to assist in wall design.

B. Performance Requirements – The contractors, material suppliers, and wall system suppliers shall have sufficient past project experience and shall be approved by the Owner's Engineer at least two weeks prior to the bid opening.

V. Submittals

The following submittals shall be made 30 days prior to the start of construction. In addition, the contractor shall provide a list of successfully completed projects along with related project references.

A. Geotechnical Reports – A geotechnical report prepared in accordance with local regulatory and industry standards shall be submitted for wall areas including any required slope stability analyses results.

B. Product Data – Manufacturer's materials specifications, installation instructions, and general recommendations. The geogrid manufacturer shall submit all strength testing data and results including connection strength test data for StoneTerra geogrid combination.

C. Plans – Engineering drawings, cross-sections, elevations, and large-scale details of elevation, typical sections, details, and connections. Plans shall be stamped and signed by a registered and qualified professional engineer in the State of _____.

D. Quality Control and Certification Submittals - Design calculations and plans for the retaining wall system. All design data shall be stamped by the Designer. The designer shall be a registered and qualified professional engineer in the State of _____. All certifications regarding ultimate and junction/connection strengths for the specified geogrids shall be submitted by the contractor.

VI. Quality Assurance

A. Pre-Construction Meeting – A meeting between the geotechnical engineer, the wall designer, the contractor, the material supplier, subcontractors, and the owner shall be held (at the site) in order to review the retaining wall design and construction requirements. A notification shall be sent to all the parties at least three 3 days in advance of the time of the meeting.

B. Designer – The firm designing the wall shall have liability insurance (Errors and Omissions) of at least $1,000,000.00 per occurrence. The designer shall be a registered professional engineer, registered in the state where the project is located.

VII. Delivery, Storage, and Handling

A. At the time of delivery, the contractor shall inspect and confirm proper type and grade of materials. All product specifications shall be reviewed to assure that all specified materials have been delivered.

B. The contractor shall store and handle all materials in accordance with manufacturer's recommendations. The contractor shall avoid excessive mud, wet concrete, epoxy, or other deleterious materials from coming in contact with and affixing to materials. Geogrids shall be stored at temperatures above – 20 degrees F (-29 degrees C). Rolled materials may be laid flat or stood on end. No damage shall occur to stored materials

C. The contractor shall discard all damaged materials and not use them in wall construction.

PART 2: PRODUCTS

I. Manufacturers

A. StoneTerra, Inc. and its licensees are the sole manufacturer of StoneTerra modular concrete units.

B. Geogrids shall be manufactured by_____.

C. Substitutions – See section _____.

II. Materials

A. StoneTerra Modular Unit

1. Concrete units are manufactured with material specifications based upon the project requirements. The engineer / owner shall determine the concrete strength, air entrainment and other specific mix design details based upon geographic climate zone and project conditions. Utilizing fresh concrete StoneTerra units shall have minimum 28-day compressive strength of 4,000 psi concrete with typical 5-7% air entrainment. Where appropriate and specified, surplus concrete may be utilized exhibiting varied concrete strength and air entrainment (minimum strength typically 2,500 - 5,800 psi). The maximum absorption of 10 pcf and adequate freeze-thaw protection (absorption by weight = 6%) shall, in general, satisfy the listed ASTM standards (C140 and C1262). Higher concrete compressive strength can result in higher cost for the blocks.

2. All individual StoneTerra units shall be free of cracks and other defects that would interfere with the placement and locking of units. Specifically, shear keys shall be free of damage.

3. StoneTerra unit dimensions such as height, width, depth, and batter shall match the details shown on the approved plans. A tolerance of ±1/8 inch per foot for all dimensions may be used.

4. Architectural features such as surficial finishes and the color of StoneTerra units shall match the details shown on the approved plans.

5. StoneTerra units shall have following dimensions (select whatever is applicable). Color application can result in higher cost for the blocks. Generally the blocks are concrete grey.
   1. StoneTerra _____
      a. Size: b. Weight:
      c. Color
   2. StoneTerra _____
      a. Size: b. Weight:
      c. Color
   3. StoneTerra _____
      a. Size: b. Weight:
      c. Color
   4. StoneTerra _____
      a. Size: b. Weight:
      c. Color
   5. StoneTerra _____
      a. Size: b. Weight:
      c. Color
   6. StoneTerra _____
      a. Size: b. Weight:
      c. Color

B. Geosynthetic Reinforcements

1. The following geogrids shall be used for soil reinforcement. The type, design strengths, and placement locations shall match details shown on plans.

2. The allowable tensile strength shall be calculated in accordance with guidelines given in Design Manual for StoneTerra Wall Systems.
   1. _____
      a. Ultimate Tensile Strength : _____lb/ft. minimum average roll value.
      b. Allowable Tensile Strength: _____lb/ft. minimum average roll value.
      c. Junction Strength : _____lb/ft.
      d. Coefficient of Direct Sliding:_____
      e. Coefficient of Interaction:_____
   2. _____
      a. Ultimate Tensile Strength : _____lb/ft. minimum average roll value.
      b. Allowable Tensile Strength: _____lb/ft. minimum average roll value.
      c. Junction Strength : _____lb/ft.
      d. Coefficient of Direct Sliding:_____
      e. Coefficient of Interaction:_____
   3. _____
      a. Ultimate Tensile Strength : _____lb/ft. minimum average roll value.
      b. Allowable Tensile Strength: _____lb/ft. minimum average roll value.
      c. Junction Strength : _____lb/ft.
      d. Coefficient of Direct Sliding:_____
      e. Coefficient of Interaction:_____

3. Connection strength data shall be part of submittals as stated in Part V.

C. Drainage Materials

1. Drainage fill materials shall consist of free draining, all-weather, coarse-grained material which is placed behind the StoneTerra units as specified on the plans. The drainage fill gradation shall be as follows as determined by the ASTM D 422 test procedure:

   100 to 75% passing in a 1-in. sieve
   50 to 75% passing a 3/4-in. sieve
   0 to 60% passing a No 4 sieve
   0 to 50% passing a No 40 sieve
   0 to 5% passing a No 200 sieve

2. The Engineer and/or Architect may specify a substitute such as a drainage composite other equivalent geosynthetic drainage materials to be approved by the designer. The drainage composite shall be – 6 oz. per sq.yd. polypropylene non-woven geotextile, AASHTO M288-96, Class 2, bonded to both sides of a polyethylene net structure, produced by _____. Minimum Allowable Transmissivity – Not less than 1.5 gallon per minute per foot of width when tested in accordance with ASTM D4716-95 at a confirming pressure of 10,000 psf.

3. The drainage collection pipe shall be installed as shown on the plans. The pipe shall be a perforated or slotted, PVC or corrugated HDPE pipe. The pipe shall be wrapped in filter fabric. The pipe shall be manufactured in accordance with ASTM D3034.

D. Reinforced Backfill Materials

1. Reinforcement backfill materials shall consist of granular materials (GP, GW, SW, SP, SM) meeting the following gradation as determined by ASTM D 422 test procedure:
   100 to 75% passing in a 2-in. sieve
   100 to 75% passing a 3/4-in. sieve
   100 to 20% passing a No 4 sieve
   0 to 60% passing a No 40 sieve
   0 to 35% passing a No 200 sieve

2. The maximum aggregate size shall be limited to ¾ inch unless appropriate values for geogrid installation damage have been used.

3. The plasticity index of materials passing No. 200 sieve shall be less than 20.

4. The pH value shall be in the range of 2 to 12 as determined by ASTM G51 procedure.

E. Accessories

1. Geotextile Filter Fabric– A polypropylene non-woven geotextile produced by _____or equal as approved by the designer with grab tensile strength (ASTM D4632) of _____lb/ft and water flow rate (ASTM D4491) of_____.

2. Erosion Control Blanket – The StoneTerra wall designer must include a reinforced, polymeric, permanent erosion control blanket on all soil structure/slope facings behind, in front, and adjacent to the retaining walls. All components shall be inert to chemicals normally encountered in a natural soil environment. The tensile strength shall be not less than_____(ASTM D5035-95). The durability criteria shall include retaining a minimum of 80 percent of strength after 1,000 hours of ultraviolet exposure (ASTM D4355-92).

PART 3: CONSTRUCTION

I. Qualifications

The contractor and the site supervisor shall have successful completed several projects including the installation of StoneTerra Wall Systems. The contractor shall carry adequate insurance and bond.

II. Excavation

A. Prior to the beginning of excavation, a StoneTerra supplier's representative experienced in StoneTerra wall construction shall be available to assist the contractor regarding wall foundation excavation, specifically the preparation of foundation subgrade including other excavation procedures related to subgrade preparation, placement of blocks, and installation of the drainage envelope behind the wall.

B. The contractor shall provide adequate excavation support during construction in accordance with local, state, and federal safety regulations. It shall be the contractor's responsibility to ensure site safety during excavation and other construction activities.

C. The subgrade shall be excavated to meet design requirements shown on grading plans. Excavations shall be made vertically to the plan elevation and horizontally to the designed geogrid lengths so that over-excavation is minimized. Width of excavation should allow for wall base and drainpipe.

D. Start excavation at the lowest wall level. If the wall steps up in one block height, the base block should be installed at the lowest level in order to establish grade and face location of the second level.

E. Overexcavated or filled areas shall be well compacted, observed, tested, and approved by a qualified geotechnical engineer.

F. A qualified geotechnical engineer shall evaluate and approve excavated materials that are used as backfill in the reinforcement zone. All backfill materials shall be protected from the weather.

III. Foundation Preparation

A. The foundation trench shall be excavated to the dimensions indicated on the construction drawings.

B. A qualified geotechnical engineer shall inspect and approve the reinforced zone and leveling pad foundation soil subgrade in order to ensure adequate bearing capacity. Subgrade soil areas not meeting required bearing strength shall be marked in the field and the contractor shall remove and replace these areas with approved fill materials.

C. Foundation subgrade soils and any backfill materials shall be compacted to a minimum of 95% of Standard Proctor Dry Density in accordance with ASTM D698 before placing the leveling pad.

IV. Leveling Pad Installation

A. The leveling pad shall consist of a minimum of 6 inch thick layer of ¾-inch minus well-graded aggregate compacted to 95% of ASTM D 1557 modified proctor density, unless specified otherwise by the design engineer.

B. A StoneTerra supplier's representative experienced in StoneTerra wall construction shall assist the contractor regarding leveling pad preparation. The wall designer may be required to inspect and approve the leveling pad prior to the placement of blocks.
The cost of the supplier representative and wall designer inspection shall be included in the installers bid.

C. As a minimum, start at the lowest wall level, locate the front face of the wall, run a string about 1 inch in front and 2 inches above the base. Use 2x6 or 2x8 and steel stakes to make a form for achieving design batter. Set the front board in line with the string at base elevation of the wall. Locate and place the backboard at a distance equal to the base width of the wall. Set elevation of backboard so that design batter can be achieved. Without moving the string line, start leap-frogging the boards in line with the string and move forward along the length of the wall. It is best to prepare the entire leveling pad before installing the blocks.

V. Unit/Block Installation

A. A small excavator or backhoe is the ideal equipment for block installation. A wire rigging with swivel hooks, OSHA approved and rated for weight of the blocks can be attached to the bucket and used for lifting, moving, and placing the blocks.

B. The contractor shall carefully place the first course of StoneTerra units only after the leveling pad has been approved.

C. Block placement should start at the lowest elevation.

D. The StoneTerra units shall be free of all protrusions and debris before installing the next course of units and/or placing the geogrid materials.

E. At the completion of the placement of each course, a string line shall be pulled to confirm that the walls geometry is being maintained.

VII. Drainage Fill, Unit Fill, and Drainage Pipe Placement

A. The StoneTerra units do not require core fill since there are no voids.

B. The drainage backfill shall be placed within an envelope of 12 inches behind the wall and shall consist of a free draining, coarse-grained granular materials, or open graded materials meeting the requirements of Section 2.II.C.1 unless specified otherwise by the designer.

C. The drainage collection pipe (minimum 4-inch diameter) shall be placed immediately behind the wall at the bottom of the wall with a minimum of 1.5% gradient to maintain a positive gravity flow into a suitable receptacle unless specified otherwise by the designer.

VIII. Reinforced Backfill Placement

A. As shown on the plans, the reinforced backfill material shall be placed in maximum lifts of 10 inches and shall be compacted to a minimum 95% Standard Proctor Dry Density in accordance with ASTM D698.

B. Only hand-operated compaction equipment shall be used within 5 feet of the back face of the StoneTerra units. This area shall be compacted to a minimum 90% of Standard Proctor Dry Density in accordance with ASTM D698-98.

C. Soil density testing shall not be performed within 5 feet of the tail of the StoneTerra™ Segmental units.

D. The backfill shall be smooth and level so that the geogrid can be placed tight and in a horizontal plane. At least 6 inches of material shall be placed over the geogrid prior to operating the tracked equipment. Swift turning and high speed of heavy equipment shall be minimized to avoid fill displacement and damage to geogrids. A maximum speed of 10mph shall be used for all heavy vehicles.

E. The excavated trench area in front of the toe of the wall shall be filled and compacted as the wall is being constructed.

F. The fill areas shall be graded or protected so that any surface water run-off is directed away from the wall face.

IX. Geogrid Installation

A. Geogrids shall be installed in accordance with manufacturer's recommendations at the design elevations and orientations as shown on the plans. The designer shall inspect on-site geogrid materials and approve it for installation.

B. Adequate tension shall be applied to geogrids and then staked on a well-prepared horizontal fill subgrade approved by a qualified geotechnical engineer for adequate compaction. The tension shall be maintained until at least 6 inches of fill is placed over the geogrid.

C. The Geogrids shall be oriented so that the design strength direction is perpendicular to the vertical plane consisting of the wall face. Geogrids shall not be overlapped in the design direction. Overlapping in the lateral direction shall be in accordance with the plans.

D. Damaged geogrids shall not be used unless approved by the designer.

X. Tolerance

Wall batter tolerance of ±1/8 in. per ft. maximum shall be allowed.

PART 4: MEASUREMENT AND PAYMENT

I. One vertical square foot of front wall surface shall be used as a unit of measurement. The front wall surface shall be considered from the top of the leveling pad (exposed bottom of wall) to the top of the wall or cap block in-place. The total quantity to be paid shall include all costs for material supply and installation.

II. Any over excavation of unsuitable materials and backfilling as directed and approved by the project geotechnical engineer and the owner shall be paid separately.

III. The quantities as shown on the plans or as approved by the designer shall be used to determine and confirm the in-place constructed wall area.