

note to user – This is a draft specification that should be edited and revised to reflect the specific conditions of a project as well as local practices and locally available materials. The draft specification provides general guidance and specific provisions may vary based on site conditions or project requirements. This draft specification should not be taken as a minimum or best practice standard.

STONE STRONG SYSTEMS

SPECIFICATIONS FOR PRECAST MODULAR BLOCK RETAINING WALL SYSTEM

(revised 5/19/21)

PART 1: GENERAL

1.01 Description

- A. Work includes furnishing and installing precast modular blocks (PMB) to the lines and grades shown on the plans and as specified herein. Also included is furnishing and installing appurtenant materials required for construction of the complete system.
- B. The contractor is solely responsible for safety. The Engineer and Owner shall not be responsible for means or methods of construction or for safety of workers or the public.

1.02 References

note to user – ASTM methods are presented w/ AASHTO comparable methods. Either set of methods may be deleted, as appropriate, for a given project

- A. ASTM - American Society for Testing and Materials (AASHTO - American Association of State and Highway Transportation Officials)
- B. ASTM C33 - Standard Specification for Concrete Aggregates (AASHTO M43)
- C. ASTM C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens (AASHTO T22)
- D. ASTM C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregate (AASHTO T27)
- E. ASTM C1776 - Standard Specification for Wet-Cast Precast Modular Retaining Wall Units
- F. ASTM D4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils (AASHTO T89 & T90)
- G. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (AASHTO T99)
- H. ASTM D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
- I. ASTM D4595 - Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method
- J. ASTM D5262 - Standard Test Method for Evaluating the Unconfined Creep Behavior of Geosynthetics
- K. ASTM D6637 - Standard Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-Rib Tensile Method

- L. ASTM D6638 - Standard Test Method for Determining Connection Strength Between Geosynthetic Reinforcement and Segmental Concrete Units (Modular Concrete Blocks)
- M. ASTM D6916 - Standard Test Method for Determining the Shear Strength Between Segmental Concrete Units

1.03 Submittals

note to user – edit submittal requirements based on type of design and other project features

- A. If a complete design is not depicted in the plans, submit for review shop drawings for the retaining wall system prepared by a Professional Engineer registered in the state/province where the project is located. The shop drawings shall indicate the layout, height, and construction details of the retaining wall system. Upon request, design calculations shall also be submitted. Minimum safety factors for design shall be as follows:

note to user – edit safety factors for specific project requirements, including conformance w/ AASHTO or CHBDC codes if required. Safety factors are not applicable to LRFD design.

	<u>Gravity Wall</u>	<u>Geosynthetic Reinforced Wall</u>
Sliding	1.5	1.5
Overturning	1.5	2.0
Bearing	2.0	2.0

- B. If stain will be applied to the wall system, a sample shall be stained on site for review and approval by the Engineer. The color sample may be part of the completed wall, but shall be located in an inconspicuous area.
- C. If an alternate geosynthetic reinforcement is included in the contractor’s design, submit manufacturer’s literature and test data for geosynthetic to be used in the reinforced wall system. Test data shall include connection strength data for geogrid with Stone Strong modular units determined in accordance with ASTM D6638, as well as geogrid tensile strength and creep data in accordance with ASTM D4595 and ASTM D5262.
- D. Submit grain size test results for aggregates to be used for the wall base and for unit fill.
- E. Submit test results on borrow material to be used for common backfill and for select backfill (if used) including Proctor and grain size or Atterberg limits results.

1.04 Delivery, Storage, and Handling

- A. Contractor shall check the materials upon delivery to assure that proper materials have been received.
- B. Contractor shall protect the materials from damage. Damaged material shall not be incorporated into the wall or the reinforced soil embankments.
- C. Contractor shall prevent excessive mud, concrete, adhesives and other substances that may adhere from coming in contact with the materials.
- D. Exposed faces of precast modular block units shall be reasonably free of chips, cracks, or stains when viewed from a distance of 10 feet (3 m).

PART 2: MATERIALS

2.01 Wall Units

- A. Precast modular blocks shall be Stone Strong units manufactured under license from Stone Strong LLC.
- B. Wall units shall conform to ASTM C1776.
- C. Dimension tolerances for precast modular blocks shall be +/- 1/8 inch (+/-3 mm) for height, +/- 1/8 inch (+/-3 mm) for length (along face), and +1/2 to -1/4 inch (+13 mm to -6 mm) for width (face to tail).

note to user – entrained air content may be adjusted based on exposure conditions (based on ACI 318) and on local practice or local agency specifications

- D. Concrete for precast modular blocks shall have a minimum 28-day compressive strength of 4,000 psi (28 MPa). Entrained air content shall be between 5 and 7%.
- E. Internal unit reinforcement or unreinforced units shall be provided according to published Stone Strong engineering guidance. Reinforced units shall be marked with the type of reinforcement.
- F. The face pattern shall be selected from the manufacturer's standard molds. The color of the units shall be natural gray. A concrete stain may be field applied to color the units if specified by the Engineer or Owner.

2.02 Geosynthetic Reinforcement

note to user – this may be omitted if no geosynthetic reinforcement is included in the design, and the Paraweb or geogrid section may be deleted if it is not applicable

- A. Geosynthetic strap reinforcement shall be Paraweb 2D-50 manufactured by Maccaferri, Inc.
- B. Geogrid reinforcement shall be SF55 or SF110 manufactured by Syntex Technical Fabrics, Inc.
- C. Substitution of a different type of geosynthetic shall not be allowed unless approved of the Architect/Engineer or Owner after submittal of shop drawings and test data.

2.03 Wall Base

note to user – aggregate type and gradation should be adjusted for locally available materials, consistent with the design. Wall base should generally be a well graded aggregate with a maximum size from 1" to 1½" (25 to 38 mm). Materials with a max size as small as ¾" (19 mm) and as large as 2½" (64 mm) may be acceptable at the discretion of the engineer. Recycled concrete aggregate may also be used subject to acceptable gradation, and cracked gravel may be acceptable in some cases. Screened aggregate, such as 57 stone, may be acceptable subject to drainage and other considerations. Some agencies may specify a concrete base. The design should account for the properties of the material specified – see design methodology documents.

- A. The wall base shall consist of dense graded crushed aggregate. A minimum of 75% of coarse material shall have 2 or more fractured faces. Wall base material shall meet the following gradation:

<u>US Standard Sieve Size</u>	<u>Metric Standard Sieve Size</u>	<u>Percent Passing</u>
1-1/2"	37.5 mm	80-100

3/4"	19.0 mm	50-90
#4	4.75 mm	0-40
#200	75 µm	0-10

- B. The contractor may substitute concrete with a minimum 28-day compressive strength of 3,000 psi (21 Mpa) for the granular base material. Concrete may be placed full thickness or as a topping over a compacted granular base. If used as a topping, the concrete shall have a minimum thickness of 3 inches (75 mm).

2.04 Unit Fill

note to user – aggregate type and gradation should be adjusted for locally available materials, consistent with the design. 57 stone is commonly used for unit fill, and this gradation usually conforms w/ the draft gradation below (although this gradation also allows for coarser materials as well). Unit fill should generally be a screened aggregate with a maximum size around 3/4" to 1 1/2" (19 to 38 mm). Materials with max size up to 2 1/2" (64 mm) may be acceptable at the discretion of the engineer. Gradation requirements are sometimes replaced with a reference to 57 stone according to ASTM C33. Recycled concrete aggregate may also be used subject to acceptable gradation, and cracked gravel may be acceptable in some cases. A well graded aggregate is not desirable for unit fill. Rather, the material should be coarse graded so that it will spill into and fill the voids within the blocks and will be free draining. The critical sieve sizes are the #4 (4.75 mm) sieve to limit loss through the block joints and a limit on the fines (less than 2% minus #200 or 75 µm sieve, but a larger sieve may be used as a proxy for fines) to maintain a free draining condition. The design should account for the properties of the material specified if the gradation varies significantly from below – see design methodology documents.

- A. Unit fill shall consist of a screened crushed aggregate. A minimum of 75% of coarse material shall have 2 or more fractured faces. Unit fill material shall meet the following gradation:

<u>US Standard Sieve Size</u>	<u>Metric Standard Sieve Size</u>	<u>Percent Passing</u>
1-1/2"	37.5 mm	100
3/4"	19.0 mm	50-90
#4	4.75 mm	0-10
#8	2.36 mm	0-5

2.05 Backfill

note to user – edit acceptable backfill to reflect on-site or select backfill as appropriate. Backfill properties must be consistent with design assumptions.

- A. If a select granular reinforced zone is indicated, it shall consist of fill sand or other clean aggregate meeting the following gradation:

note to user – edit gradation for locally available materials, or replace w/ reference to DOT or ASTM gradation

<u>US Standard Sieve Size</u>	<u>Metric Standard Sieve Size</u>	<u>Percent Passing</u>
3/4"	19.0 mm	100
#200	75 µm	0-5

note to user – edit properties of on-site soil or borrow based on local conditions/practices

- B. All other backfill behind and in front of the wall shall consist of suitable on-site soil or imported borrow and shall be approved by the Geotechnical Engineer. Backfill shall generally consist of sands, silts, or lean clays with a liquid limit less than 45 and a plasticity index less than 20. Fat clay soils, cobbles, and large rock should generally be avoided

unless approved by the Geotechnical Engineer based on local practices. Frozen soils, excessively wet or dry soils, debris, and deleterious materials should not be used.

2.06 Drain Tile

note to user – drain tile may be omitted at the discretion of the engineer where ground water is not expected and weeping through the face joints will be sufficient to prevent buildup of hydrostatic pressure

- A. Drain tile shall be a perforated or slotted PVC or corrugated HDPE pipe. The drain tile should be connected to storm drains or daylighted at low points and/or periodically along the wall alignment as shown on the plans.

2.07 Geotextile Fabric

note to user – for gravity walls, a geotextile filter may be included when seepage from the backfill zone (due to high water table, inundation, etc) is expected to foul the drainage aggregate inside the units or where separation from the backfill zone is required for other reasons. Geotextile may be deleted in other cases at the discretion of the engineer. In most cases, this section may be deleted.

- A. Provide a geotextile filter for separation from backfill at the tails of the blocks. The geotextile shall be a needle punched non-woven fabric with a minimum grab tensile strength of 120 pounds (534 N). The geotextile may cover the entire back face of the blocks or may be cut in strips to cover the gaps between tail units with a minimum of 6 inches (150 mm) of overlap over the concrete tail on both sides.

2.08 Concrete for Tail Extensions

note to user – this may be omitted if no cast in place tail extensions are included in the design

- A. Concrete for tail extensions shall have a minimum 28-day compressive strength of 3,000 psi (21 MPa). Higher mix strength may be necessary to achieve a strength of 2,000 psi (14 MPa) before the wall is backfilled above the level of the tail extension.
- B. Concrete shall have entrained air content between 5% and 7%.

PART 3: EXECUTION

3.01 Excavation

- A. Excavate as required for installation of the retaining wall system. Excavate to the base level for a sufficient distance behind the face to permit installation of the base.
- B. Slope or shore excavation as necessary for safety and for conformance with applicable OSHA requirements.

3.02 Wall Base

- A. Foundation soils shall be excavated to the dimensions shown on the plans. Foundation soil shall be observed by the Geotechnical Engineer to confirm that the bearing soils are similar to the design conditions or assumptions.
- B. Construct the wall base to the lines and grades shown on the plans. Place and consolidate concrete, strike, and finish plane and level. Overexcavated areas shall be filled with additional concrete or granular base material. Compact granular base material to provide a hard and level surface to support the wall units. Base material shall be compacted to a

minimum of 95 percent of the maximum dry density (ASTM D698, Standard Proctor). Final base elevation shall be within 0.1 feet (30 mm) of plan elevation.

- C. Prepare and smooth the granular material to ensure complete contact of the first course with the base. The base may be dressed with fine aggregate to aid leveling.

3.03 Unit Installation

- A. Place the first course of units directly on the wall base. Check units for level and alignment. Units shall be within 1/8 inch (3 mm) of level from end to end and from front to back. Adjacent units should be in contact. If possible, begin placing units at the lowest section of the wall.
- B. Fill all voids between and within the blocks with granular unit fill. Additional unit fill is not required behind the units, but may be placed for the convenience of the contractor.
- C. Place backfill behind the units in maximum loose lifts of 8 inches (200 mm) and compact. Compact all backfill to a minimum of 95 percent of the maximum dry density (ASTM D698, Standard Proctor). For cohesive soils, the moisture content at the time of compaction should be adjusted to within -2 and +3 percent of optimum. Place backfill in successive lifts until level with the top of the facing unit.
- D. Remove all excess aggregate and other materials from the top of the units before laying up the next course.

note to user – for a geogrid reinforced wall, delete the following sections on Paraweb installation

- E. For Paraweb reinforced walls, place the correct Paraweb strap at the locations and elevations shown on the plans or the shop drawings. Paraweb reinforcement shall be placed horizontally on compacted backfill in a V-layout. The length of the Paraweb is measured from the embedded connector in the back of the facing unit. Wrap the Paraweb strap around the embedded connector at the point of the V-shaped strap layout. Paraweb straps may be spliced following the manufacturer's guidance.
- F. Ends of the Paraweb straps shall be staked or held in place. Slack shall be removed from straps using an approved method.
- G. Do not operate equipment directly on the Paraweb straps. A minimum backfill depth of 6 inches (150 mm) should be placed before operating equipment over the reinforcing straps.

note to user – for a Paraweb reinforced wall, delete the following sections on geogrid installation

- H. For geogrid reinforced walls, place the correct geogrid at the locations and elevations shown on the plans or the shop drawings. Geogrid reinforcement shall be placed horizontally on compacted backfill. The length of the geogrid is measured from the front face of the wall. Extend the grid onto the front face flange of the facing unit. Orient the geogrid with the strong axis (machine direction) placed perpendicular to the wall face. Geogrid shall not be spliced by any means in the roll direction.
- I. Geogrids shall be placed side by side to provide complete coverage along the wall face. No overlap is required between adjacent grids on straight sections of the wall. On convex curves, place a minimum of 3 inches (75 mm) of backfill material between overlapping geogrid layers.

- J. Pull geogrids taught and stake or hold the loose end in place before placing the next course of backfill. Backfill shall be placed, spread, and compacted in such a manner that minimizes the development of wrinkles in the geogrid and/or movement of the geogrid. Do not operate equipment directly on the geogrid. A minimum backfill depth of 6 inches (150 mm) should be placed before operating equipment over the grids.

note to user – edit setbacks if a vertical face is intended

- K. Place the next course of precast modular block units in running bond with the previous course. Place the web recess over the alignment hoop protruding from the unit below, and pull the unit forward to contact the hoop. Batter should be within ¼ inch (6 mm) tolerance (4 inches/102 mm from 24 SF unit below, 2 inches/51 mm from 6 SF unit below).
- L. Continue placing successive courses to the elevations shown on the plans. Construct wall in level stages, placing the units at each course for the entire length of the wall, if possible. Unit fill and backfill should be placed to the level of the top of the facing unit before placing the next course.
- M. Provide temporary swales to divert runoff away from wall excavation and away from face.
- N. Final grade above and below the retaining wall shall provide for positive drainage and prevent ponding. Protect completed wall from other construction. Do not operate large equipment or store materials above the wall that exceed the design surcharge loads.

note to user – edit if alternate connection is used, including steel reinforcement into voids, or delete if tail extensions are not used

- O. Where tail extensions are indicated on the plans, concrete shall be placed in a continuous placement inside the side voids between the blocks extending to the minimum width behind the blocks indicated on the drawings. Tail extensions may formed or may be placed directly against a cut embankment. Tail extensions should be placed in lifts not to exceed 4½ feet (1.4 m) until the previous lift has fully set. The tail extension should be allowed to reach 2,000 psi (14 MPa) compressive strength before backfill is placed above the top of the extension.

PART 4: CONSTRUCTION QUALITY CONTROL AND ASSURANCE

4.01 Construction Quality Control

- A. The contractor is responsible to ensure that all installation and materials meet the quality specified in the construction drawings.
- B. The contractor shall verify that installation is in accordance with the specifications and construction drawings.

4.02 Quality Assurance

- A. The owner is responsible to engage testing and inspection services to provide independent quality construction assurance.
- B. Compaction testing shall be done a minimum of every 1 foot (300 mm) of vertical fill and every 100 lineal feet (30 m) along the wall.
- C. Testing shall be done at a variety of locations to cover the entire backfill zone.

- D. The independent inspection professional should perform sufficient testing and observation to verify that wall installation substantially conforms to the design drawings and specifications.

END OF SECTION