LondonBoulder™
Where Strength Meets Style

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Big Block Engineering & Installation Guide

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With the natural aesthetics of a boulder wall and the strength and reliability of traditional segmental retaining wall units, LondonBoulder is the perfect solution when strength and style are a necessity.

LondonBoulder™

Where Strength Meets Style

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Designing a wall involves more than just calculating the number of courses and amount of grid it will take to cover a desired length.

When bringing a project from idea to reality, careful planning at the early stages goes a long way toward minimizing costs, repairs and other project setbacks. Proper consideration of construction site features, obstacles and constraints is essential for a cost-effective design and will influence the final product.

TERRAIN GEOMETRY

The first consideration when planning a LondonBoulder wall is to look at the site topography. Careful examination of changes in terrain elevation will help reduce excavation costs. Plan for adequate drainage and other remedies to channel water away from your wall.

Other important aspects to consider at this stage are whether adjacent construction, waterways or other terrain features could have an effect on the design and performance of the wall in the future.

GRADING

Careful examination of terrain grading both above and below the planned wall is essential. Slopes above the wall will create overloads, whereas a sloping grade at the wall footing typically decreases the available resistance to the design loads.

Grading can also create problems if it channels or retains water on or near the wall.

NEARBY STRUCTURES

If they are close to the wall, loads created by structures such as buildings, parking lots, storage areas, etc. can have an impact on final design. Depending on the circumstances and relative duration, these loads may be classified as either LIVE or DEAD.

For example, slopes are generally considered DEAD loads, whereas loads coming from parking lots may be classified as LIVE, due to their shorter duration. DEAD loads, e.g., building loads, or loads from a tiered wall may contribute to the overall stability of the wall, depending on closeness to the wall edge. Surcharges increase the stress on block and reinforcing grids. Keep in mind that these facts will contribute to a balanced design.

LIVE loads, such as those resulting from bulk storage, vehicular traffic, etc. may act both as stabilizing and destabilizing forces in your design. Typically, a conservative design approach is to neglect any live loads as part of the resisting set of forces in design.

As a rule of thumb, surcharge loads that are at a distance of twice the height of a wall below can be neglected in a design.

UTILITIES

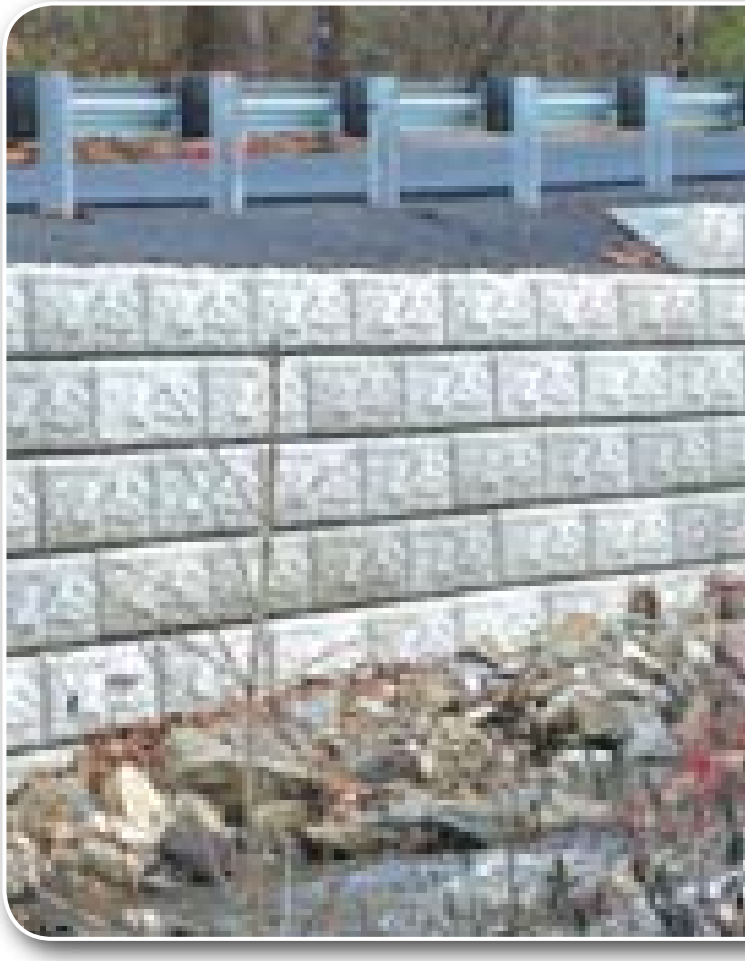
Utilities should be designed to withstand any loads from the wall system. All utilities that have a potential for leaking (water mains, sprinkler systems) should be moved out of the reinforced soil zone if possible.

SOILS

Soils are important not only because they will ultimately bear the weight of the designed wall structure, but also because their properties directly affect the design.

Typically, well-graded coarse sands have better design properties than finer soils, like clay. Particles in sand fill voids and interlock better than uniform granular soils or clays, resulting in stronger structures.

Soils that are expansive, or organic (peats, etc.) should be avoided as fill material when building walls. Granular soils that are too coarse or sharp can damage the reinforcing grid. Consult the grid company for their installation damage reduction factor for a particular soil, that info can be used in the design, and the soil can be used. If the site has unsuitable soils (disturbed soils, soft, expansive, chemically aggressive, etc.) they must be excavated and replaced with appropriate materials prior to any other work.



WATER

One crucial site characteristic that must be checked before any design is carried out is the presence of groundwater. The presence of a water table too close to the bottom of the foundation pad (less than 2/3 the height of the wall), or suspicion of a seasonally shifting water table can dramatically reduce the integrity of the wall if left unchecked.

Also, be sure to check for the presence of waterways or moving floodwaters that could cause scour of the foundation at the bottom of the wall. Make sure that terrain features do not bring surface water near the wall. If that is the case, the design should include details to ensure water gets diverted from the structure. These include swales over and around the top of the wall, slopes,"curling" the ends of the wall into the slope or bank, impervious soil tightly compacted at key locations, etc. These provisions should not be confused with internal drainage within the wall structure, typically comprised of granular aggregate drainage directly behind the wall face, drain tile pipes, and chimney drains behind the reinforced soil mass.

SETBACK

One of the benefits of LondonBoulder is its ability to be built both vertically and with two setbacks. This level of versatility allows the LondonBoulder line to be useful in a variety of environments while meeting a number of landscaping needs. However, careful consideration must be taken when determining whether to build the wall with or without a setback.

Although setback walls have the ability to retain larger amounts of earth than vertical walls, they add a level of difficulty when it comes to project planning and design. Each course in a setback wall has a setback of 2 or 6 inches. If this setback is not considered, the desired layout may be impossible to realize once the minimum radius of curvature of the LondonBoulder units has been reached.

All segmental retaining walls designed with active earth pressure theory need to rotate slightly during or after construction. This rotation is caused by construction equipment, tensioning of the geosynthetic reinforcement, and because the soils have to move slightly to achieve stability. The rotation can be as little as 1/2 of a degree or up to several degrees, depending on soil types and the care taken by the contractor. Because of this, vertical walls may not be vertical after construction, but may be leaning out slightly.

UNREINFORCED WALLS

A retaining wall is a structure that resists the forces from a soil mass by virtue of its own weight. In many cases, a simple gravity wall (with no geogrid reinforcement required) will be all that is needed to retain a soil mass. The soil is kept in place by the sole weight of the stacked concrete blocks. When this weight alone is not enough, the use of reinforcement grid brings together a larger mass of soil to counteract the pressures of the retained soil.

Generally, if the terrain is level, with appropriate soil and no surcharges or water masses nearby, unreinforced vertical walls can be built up a maximum height of 10.5 ft (with 34 degree soil), while walls that are installed with a 6" setback can reach maximum heights of 15 ft (with 34 degree soil). If soil and terrain conditions are not ideal, it is strongly recommended that the project be reviewed by a qualified licensed professional (P.E.). **See "Unreinforced Height Limits for LondonBoulder" for more detailed information.**

REINFORCED WALLS

When your wall design calls for taller walls, or incorporates special conditions such as tiers, slopes, or surcharges behind the wall, reinforcing grid or "Double Walls" may be required to stabilize the wall. (See page 14 for additional information on Double Walls.) Grid layers work by bringing together a larger mass to aid the wall in resisting the forces exerted by the retained soil. See grid reinforcement details beginning on page 17.

Unreinforced Height Limits for LondonBoulder

Assumptions related to engineering:

- No surcharge or back slope present
- Soil unit weight of 120 pcf
- Minimum 1' embedment
- Backfill compacted to minimum 95% of the standard Proctor maximum dry density.
- Safety factors: 1.5 against sliding; 2.0 against overturning
- Heights apply only to soil type with indicated friction angles
- Construction follows adequate industry practice

The following chart represents height limits related to vertical or setback walls constructed in soil with varying degrees of friction angles. Chart does not include checks for global stability or presence of water.

SOIL	NO SETBACK	2" SETBACK	6" SETBACK
$\phi = 26°$	7.5'	10.5'	12'
$\phi = 28°$	7.5'	10.5'	12'
$\phi = 30°$	9.0'	12'	13.5'
$\phi = 32°$	9.0'	12'	13.5'
$\phi = 34°$	10.5'	13.5'	15'

This chart is for estimating tasks and reference only. It is the user's responsibility to ensure that a final, project-specific design is reviewed, approved, and sealed by a registered Professional Engineer, based on actual soil conditions. It is the project owner's responsibility to ensure the adequacy of the designed retaining wall incorporated into the overall project through a specification. The specification should include factors which affect the overall integrity of the retaining wall such as location, interaction with other project components, and engineering aspects including but not limited to site soil bearing capacity, global slope stability, presence of underground or surface water, etc. Specification of excavation, trenching or any other construction procedures and corresponding safety specifications are the responsibility of the installer, who shall adhere to sound industry practice and provide additional support during construction if needed.

EXCAVATION/BASE PREPARATION

1. LondonBoulder recommends that wall elevations be set using a laser level and stakes prior to excavation. This will greatly enhance the efficiency and accuracy of the entire project.

2. Foundation soil shall be excavated to the lines and grades of the construction drawings and as required for base course installation. Use caution to ensure that the foundation is not disturbed beyond the indicated depths. As shown in **Figure A**, base trench shall be excavated to a minimum of 60" wide and 6" deep. Use compacted backfill material to fill over-excavated areas. It is permissible to use a layer of non-woven landscape fabric along the three sides of the trench to maintain a barrier between the surrounding foundation and the base material to be put down later.

a. Using granular, inorganic material such as crushed road base material, crushed stone, or recycled concrete, place the base leveling pad in the excavated trench such that it maintains a width of 60" and a minimum depth of 6" after compaction. Compaction should meet or exceed 95% Standard Proctor and should be achieved through the use of a mechanical plate compactor.

- or -

b. Lean concrete with a minimum 28-day compressive strength of 500 psi may be substituted for the granular base material. Granular base material may also be top-dressed with a minimum 3" thick layer of lean and unreinforced concrete. Reinforced footings must be placed below the frost line.

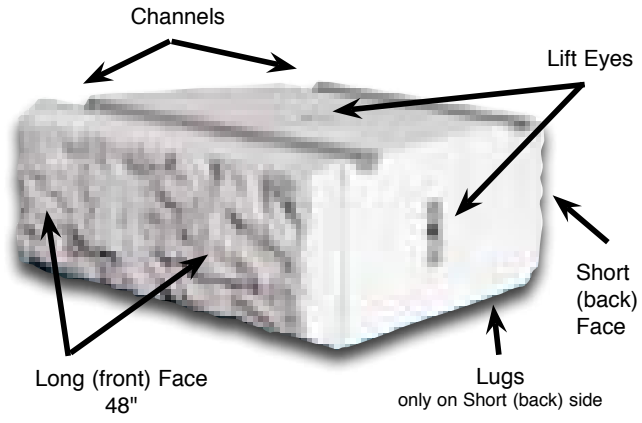
4. Final base must be uniform, level, and well compacted to provide the best possibility for a smooth, hassle-free wall installation. Achieving this standard in the base will also help to limit the number of future repairs that may be necessary due to sections of sagging wall and other base-related failures.

5. Level compacted base material from side to side and front to back.

6. A drainage pipe should be installed in all walls. The drainage collection pipe should daylight into a storm sewer manhole or to a sloped area lower than the pipes behind the walls. The main collection drainpipe just behind the block facing shall be a minimum of 4" in diameter. **See Figure D on page 8.**

Recommended Construction Tolerances		
Vertical	± 1" / 10 ft	3" maximum
Horizontal	Straight lines: ± 1" / 10 ft	3" maximum
Rotation	From design wall batter: 2º	
Bulging	1.00" / 10 ft	

ANATOMY OF THE LONDONBOULDER



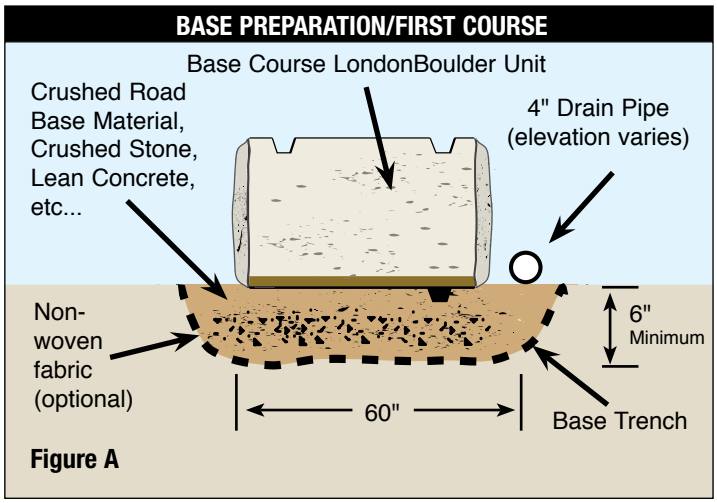
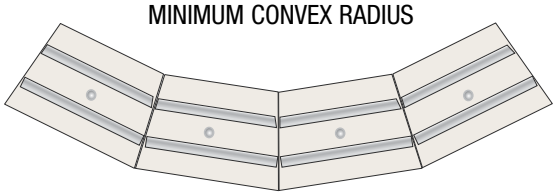


Figure A

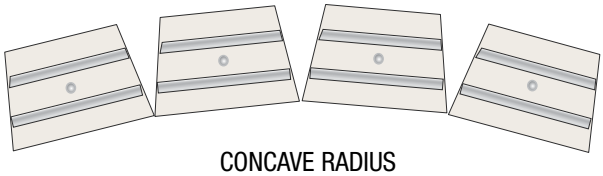
TOP VIEW - CURVED RETAINING WALL

MINIMUM CONVEX RADIUS



Minimum Convex Radius with Setback	
Courses	**R (*)**
1	10'-09"
2	11'-05"
3	12'-00"
4	12'-08"
5	13'-04"
6	14'-00"
7	14'-07"
8	15'-03"
9	15'-11"
10	16'-07"
11	17'-03"
12	17'-10"
13	18'-06"
14	19'-02"
15	19'-10"
16	20'-06"

(*) Top course or one-course wall leave a 1/4" gap at the back of the block.



CONCAVE RADIUS

Figure B

SETTING THE FIRST COURSE

1. Always start the base course at the lowest elevation of the wall, if possible. In the case of a base elevation that varies, refer to **Figure C**. LondonBoulder recommends a two block overlap when stepping up from one course to the next.

2. Place the first course of LondonBoulders directly on the leveling base pad, check to ensure that they are properly aligned and leveled. The bottom surface of each unit should be in full contact with the base. If units have lugs, removing them may be preferred prior to placing as base course. Adjacent units should be in contact with one another at the front face if constructing a retaining wall, and along all inside edges if constructing a partition wall (this is accomplished by reversing every other trapezoidal unit inside the two end units).

3. Alignment of a straight wall may be best achieved by using a string line or laser level on the machined edge of the blocks. If building a convex or concave wall, it may be helpful to run a radius string from an established center point. **See Figure B** for minimum radius information.

4. Place perforated or slotted PVC or corrugated HDPE pipe behind the course providing the optimal drainage of LondonBoulder units. LondonBoulder recommends that the drain pipe be at least 4" in diameter and surrounded by a minimum of 1 foot of drainage stone. In special situations where water and drainage play a bigger role in the design, “weep holes”, larger drainage stone, larger drain pipe with sock, and/or filter fabric behind the drainage stone may be warranted. Contact a P.E. for recommendations and details.

TYPICAL STEPPING-UP BOULDER CONSTRUCTION DETAIL

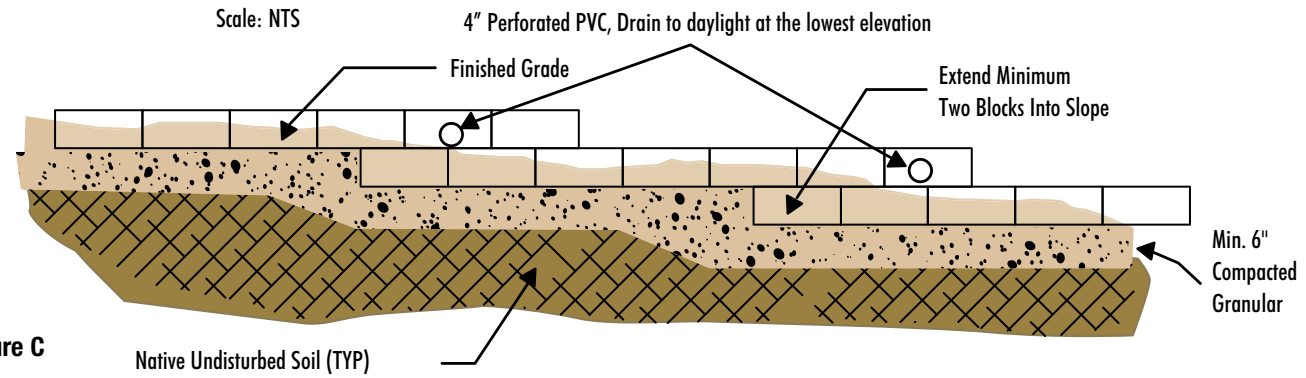
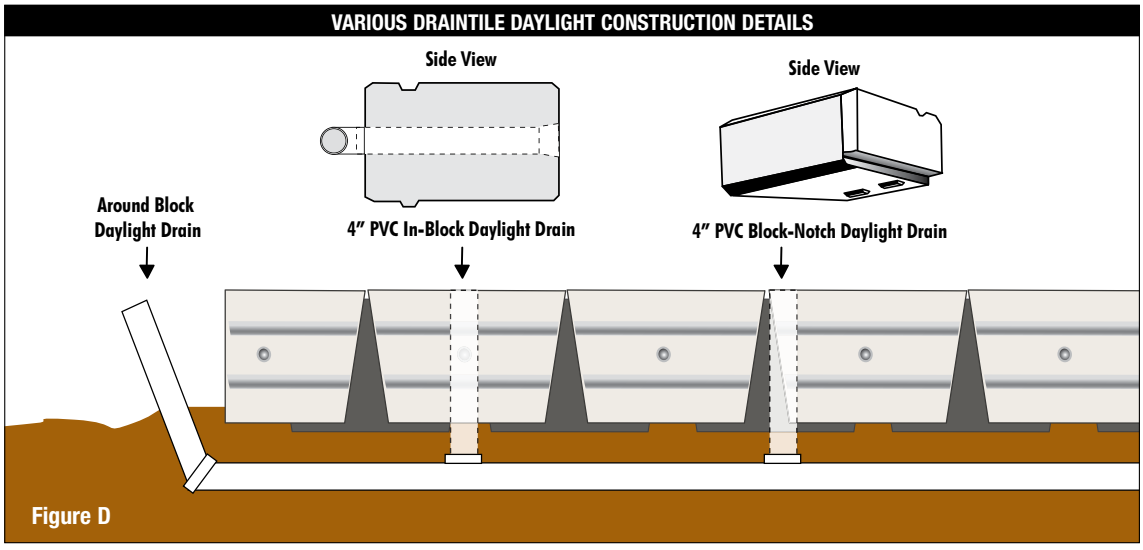


Figure C

BACKFILL

1. All drainage material in the drainfield and infill soils within 3 feet of the wall must be properly compacted. Use appropriate compaction equipment for the soils.
2. Compact in maximum 9" lifts – i.e. compaction should occur a minimum of 2 times with each course of LondonBoulder units set.
3. Place drainage aggregate behind and up to the height of the LondonBoulder wall. Drainage aggregate shall be placed to a minimum thickness of 12" measured from the back of the LondonBoulder unit. Reference photo to the right.
4. If installing a retaining wall, it is likely that there will be triangular voids between each LondonBoulder that are caused by the trapezoidal shape of the units. (Note that this void will not be present if installing a partition wall). Fill this void with 3/4" drainage rock or equivalent. Reference photo to the right.
5. Large rock and fat clay soils should generally be avoided as backfill material unless approved by a qualified engineer. In addition, soils that are excessively wet, dry, frozen, or inundated with debris should not be used.
6. If required, install geotextile filter fabric between the compacted backfill material and compacted infill soil.
7. If using geogrid reinforcement, be sure to avoid using compacting equipment directly on geogrid. Place the next 9" lift of soil on top of the grid before compacting.



INSTALLING SUCCESSIVE COURSES

1. Ensure the drainage aggregate is level with, or slightly below the top of the LondonBoulder unit.
2. Clean all excess material from the top of the units as well as any debris that may have fallen into the channels that run parallel across the top of each LondonBoulder. Even a small stone can create unevenness or a wobble.
3. Place the next row of LondonBoulder units with the seams offset from the seams of the units below. (**See Photo E** for additional detail on establishing a 1/2 running bond.
4. If installing a 6" setback place the lugs to engage the back edge of the units below. 2" and 0" setback LondonBoulders are manufactured for the lugs to set into the channel of the unit below.
5. Set up a string line horizontally down the wall to ensure wall straightness. Adjust units as needed to form straight lines and smooth curves. Make sure to check each block to certify that it is level from front to back and side to side. Adjust if necessary. Qualified geogrid material can be used as a shim to make minor corrections in level.
6. Place drainage aggregate and infill soil as stated previously.
7. Repeat these steps until the wall reaches its final height.

Photo E

USING THE GEOGRID SYSTEM

1. Install units up to the designated height of the first grid layer, making sure to backfill and compact behind the wall to a depth equal to the designed grid length.
2. Cut grid to design length as shown on the plans. Make sure the grid is positioned on the top of the unit course 2" to 3" from the face. This will help to keep each successive course flat. Install the grid with the design strength direction perpendicular to the wall face. Seams or overlaps of grid parallel to the wall face are not permitted.
3. The geogrid reinforcement must be laid level upon the block and upon level backfill, compacted to 95% Standard Proctor density.
4. Remove all slack in the geogrid, then anchor it to the compacted backfill and place the next level of LondonBoulders and backfill. These units should be placed on top of the grid.
5. Only hand-operated equipment should be allowed within 3 feet of the wall. Track construction equipment shall not be operated on less than 6" of compacted infill material.

GEOGRID LAYOUT IN CURVES AND CORNERS

Curves and corners in designs need additional considerations for the correct layout of the reinforcing grid. Interior corners will invariably leave gaps between grid layers, due to the curvature. To cover these gaps, install additional reinforcement in places where gaps occur on the next course above prior to backfilling. **See Figure F.**

In addition, square corners require that the 90° gap be filled with an extension of the reinforcing sheet equal to 25% of the total wall height, on alternate sides of the gap as you go up. **See Figure H on page 11.** If it's not possible to add on the next course to put 3" of fill between the grid layers.

In contrast, exterior corners will always cause reinforcing grids to overlap, which in turn dramatically reduces the load carrying capacity of the grid. To correct this, a minimum of 3" fill must be placed between sheets at those overlap areas prior to backfilling that lift, as shown in **Figure G, and Figure I on page 11.**

INSIDE CURVE GRID LAYOUT (TYP)

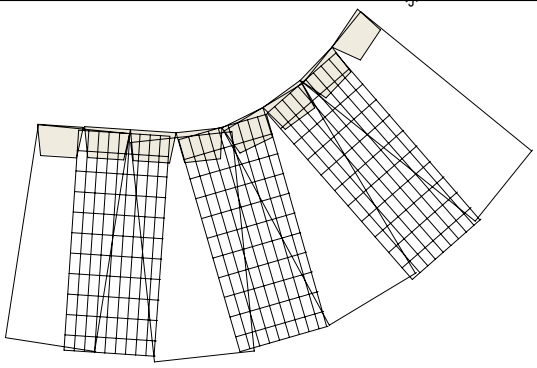
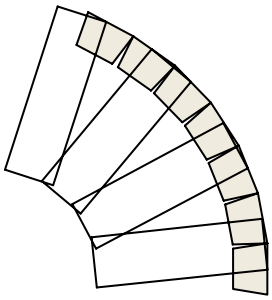


Figure F

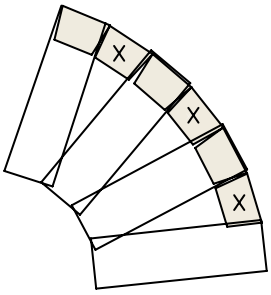
OUTSIDE CURVE GRID LAYOUT (TYP)

Scale: NTS

STEP #1:
Place grid so as to minimize overlap. Place 3" fill between any overlapping edges



STEP #2:
Install the next block course. Mark those blocks where there were gaps left in the grid below. Backfill and compact.



STEP #3:
Place grid over the areas where gaps were left. Backfill and compact. If overlapping, fill as in Step #1.

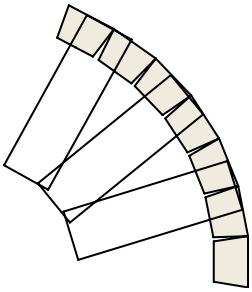


Figure G

INSIDE SQUARE CORNER REINFORCEMENT LAYOUT (TYP)

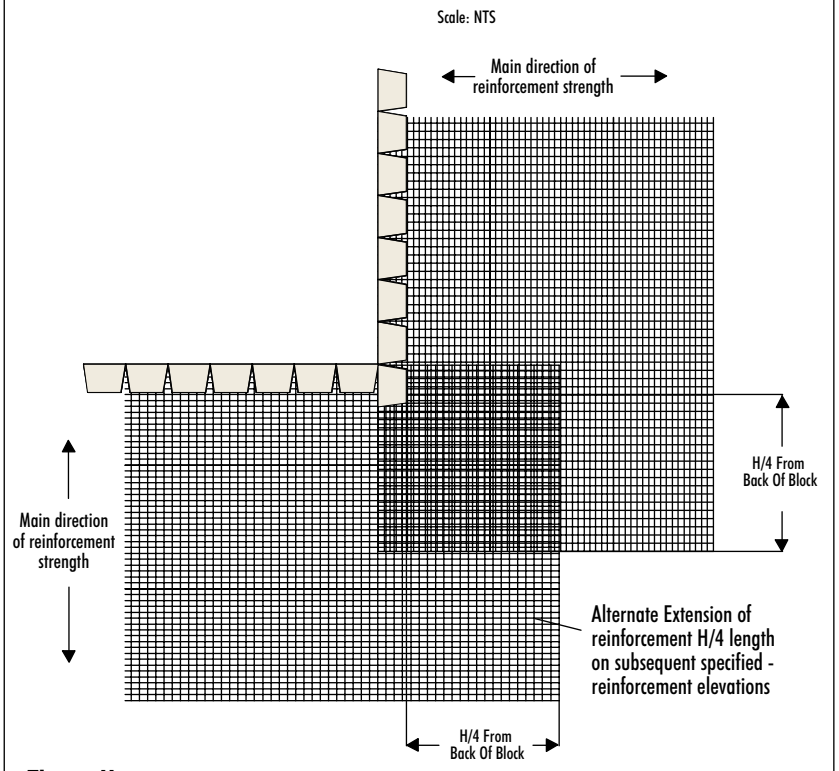


Figure H

OUTSIDE SQUARE CORNER REINFORCEMENT LAYOUT (TYP)

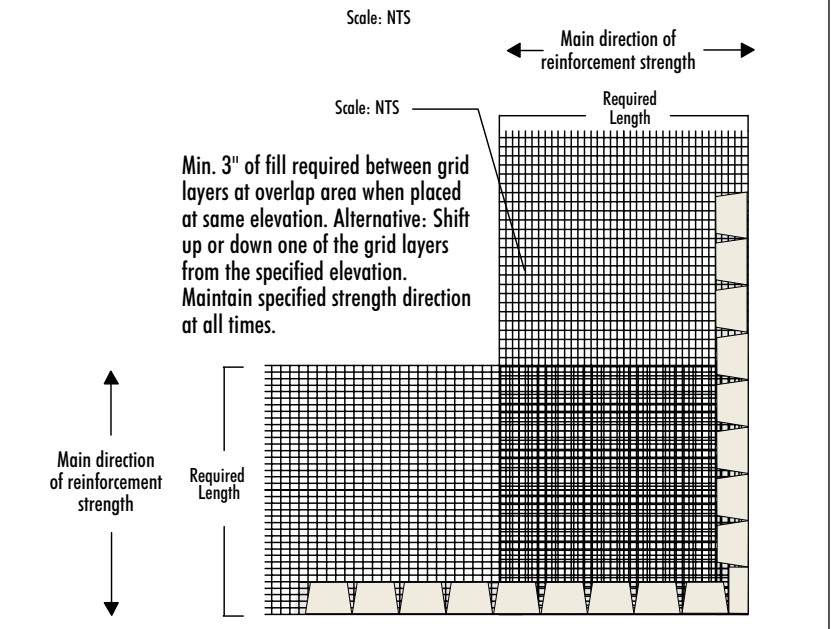


Figure I

CAPPING

1. Make sure the surface of the Cap Boulder, and the block the Cap Boulder is being placed on, is dry and free of debris.
2. Set cap unit in the same manner as LondonBoulder units.
3. The back side of the Cap Boulder is recessed 8 inches to allow for the application of soil, sod, rock, mulch or any other fill material the end user deems necessary. The Cap Boulder's sides are tapered to allow for a radius wall if desired. LondonBoulder also offers a 6" cap boulder as an alternative for capping. 6" caps are designed to be placed on the top course using concrete adhesive between it and the course below.
4. Each end of a course of Cap Boulders can be finished with a Left and/or Right Cap Corner.
5. Careful consideration must be taken when using the Cap Corner units at both ends of a wall with two 90° corners. Given the set dimensions of the Cap Corners at 24", some calculations must be made to ensure that it is possible to fit a set number of units between the two end units. Cutting of Cap Boulders may be required to maintain running bond or to get all caps to fit without gaps.

CAP BOULDER

CAP CORNER BOULDER

6" CAP BOULDER

90 DEGREE CORNERS

Utilizing its rebar pinning method, LondonBoulder's 90° Return Corner provides a simple, 1-unit system to turn a 90° corner without losing retention strength. Each 90° Return Corner is manufactured with a 3" hole running vertically through the unit. By alternately "flipping and turning" each course, these holes will create a corner core into which rebar can be inserted. Since these units are manufactured without lugs for versatility, the rebar pinning system serves as the shear connection for a strong, reliable corner. **See Figure J.**

This method of achieving 90° Corners also continues the 1/2 bond both directions, creating a consistent finish.

90 DEGREE CORNER

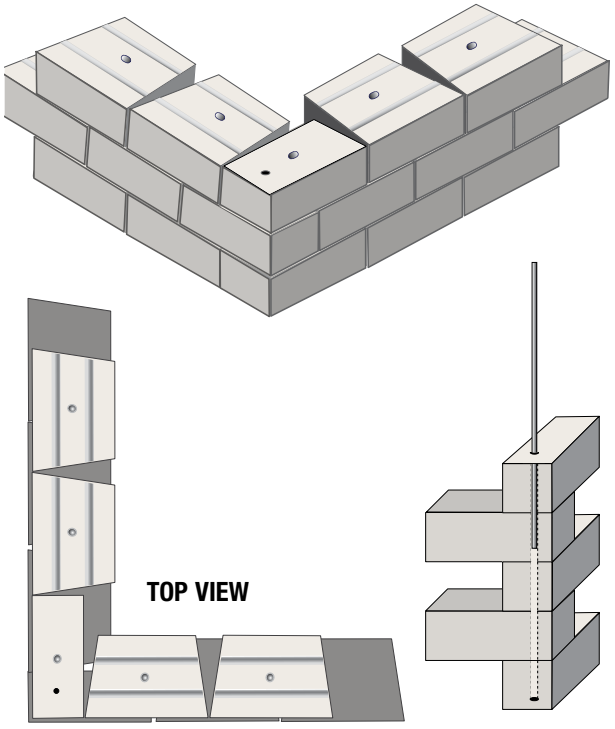


Figure J

SEAWALL

With minor changes to the base leveling pad and the addition of rip rap, LondonBoulder walls can be installed in water settings. However, due to the variety of site-specific variables and restrictions, no wall height charts can be provided for seawall applications. Consult your P.E. for specific details and stamped drawings. **See Figure K.**

TYPICAL SEAWALL DETAIL

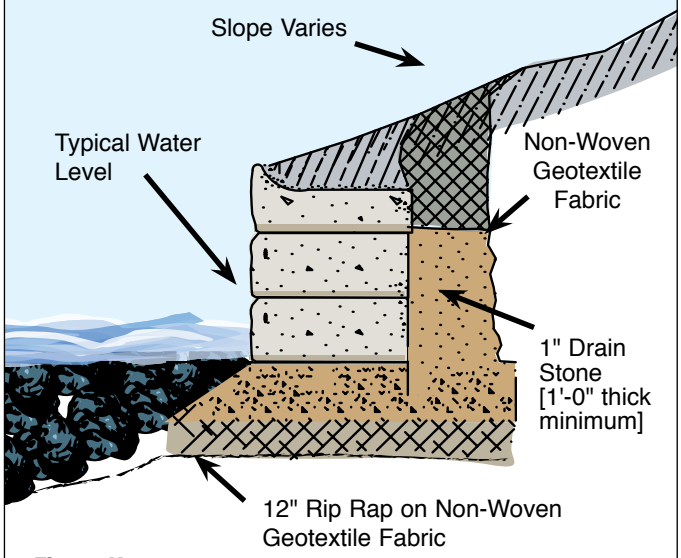
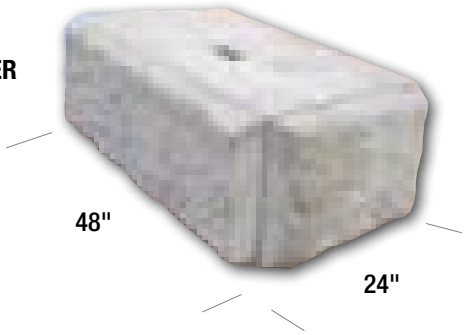


Figure K

90 DEGREE RETURN BOULDER



FREE-STANDING PARTITION WALL

With a combination of unique and versatile features including vertical capabilities and a textured face on two sides, the LondonBoulder line can be easily turned into a free standing partition wall.

DOUBLE WALL

In certain conditions it may be beneficial or necessary to limit site excavation and geogrid installation with the presence of a double wall. Double walls require less excavation and provide earth retention benefits similar to that of geogrid. Typical double walls are only a portion of the height, and do not necessarily run the full length of the finished, exposed wall. **See Figure L** Consult your local P.E. for details regarding the application of double walls at specific sites.

TOP VIEW - DOUBLE WALL

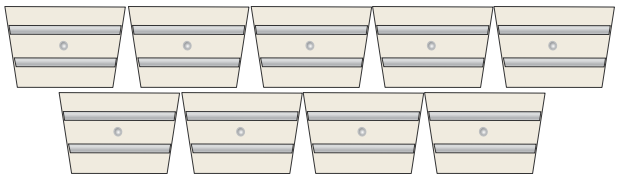


Figure L

Full Boulder
48" x 18" x 42"
Weight: 2160 lbs.
Sq. Ft. / Block: 6 sq. ft.

6" Cap Block
6" x 40" x 34"
Weight: 740 lbs.
Sq. Ft. / Block: 1.7 sq. ft.

90 Degree Return
48" x 18" x 24"
Weight: 1100 lbs.
Sq. Ft. / Block: 9 sq. ft.

1/2 Boulder
24" x 18" x 42"
Weight: 900 lbs.
Sq. Ft. / Block: 3 sq. ft.

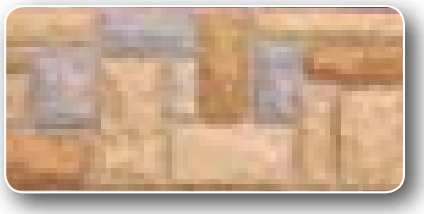
Cap Boulder
48" x 18" x 38"
Weight: 1260 lbs.
Sq. Ft. / Block: 6 sq. ft.

Right Cap Corner
24" x 18" x 34"
Weight: 660 lbs.
Sq. Ft. / Block: 7.25 sq. ft.

Left Cap Corner
24" x 18" x 34"
Weight: 660 lbs.
Sq. Ft. / Block: 7.25 sq. ft.

AVAILABLE IN THREE FACE TEXTURES

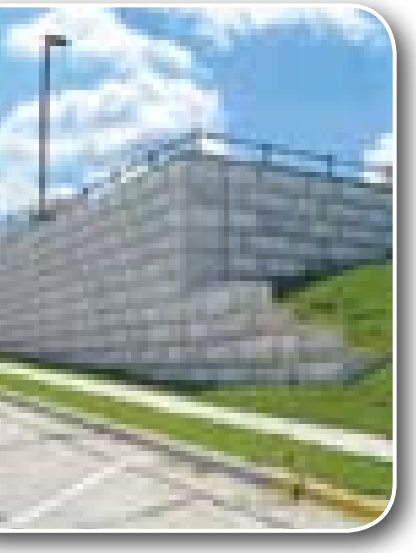
Limestone Face



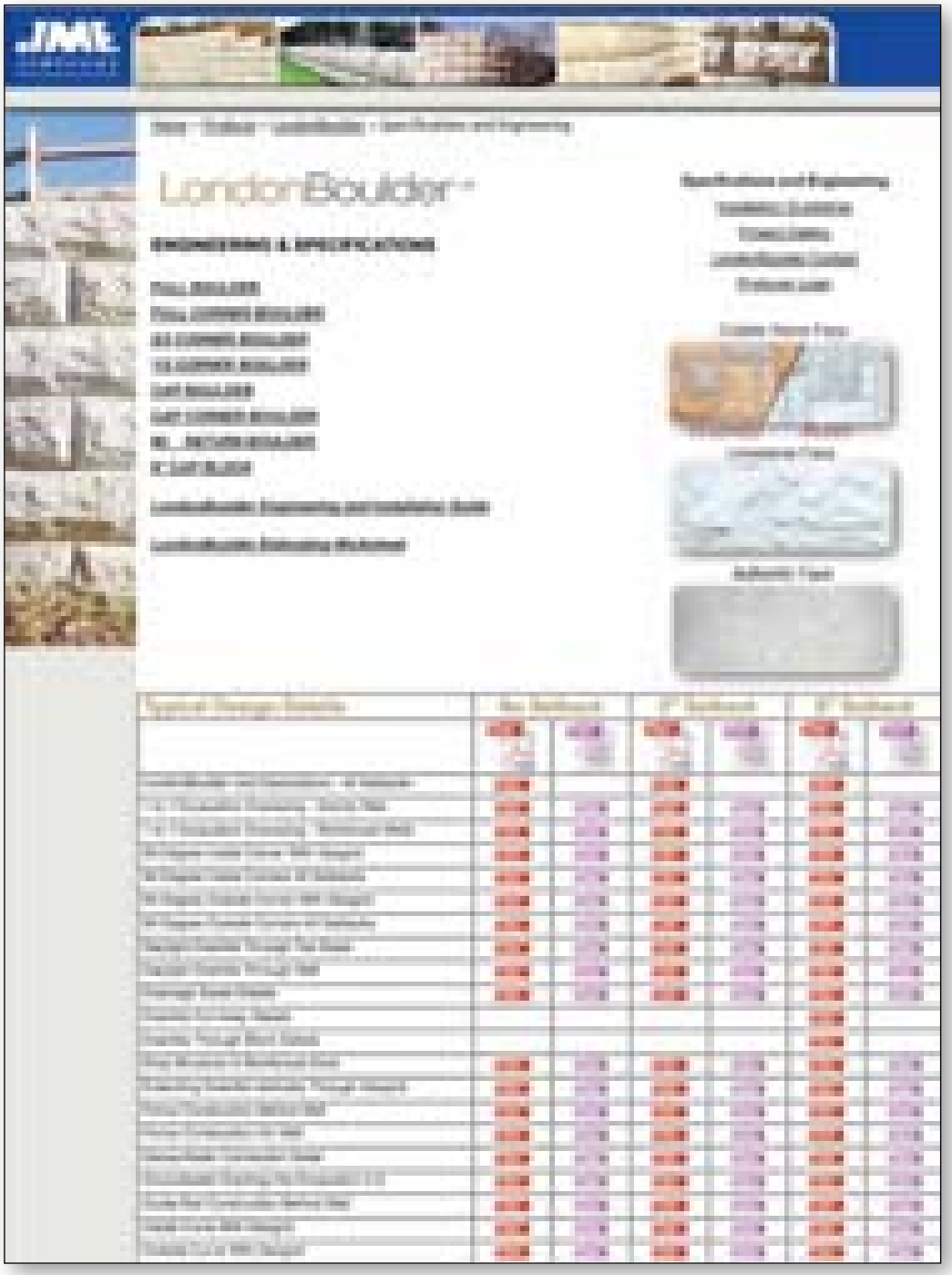
Stained Cobble Stone Face

Authentic Face

Not all face textures are available in every market. Check with your local producer for more information.

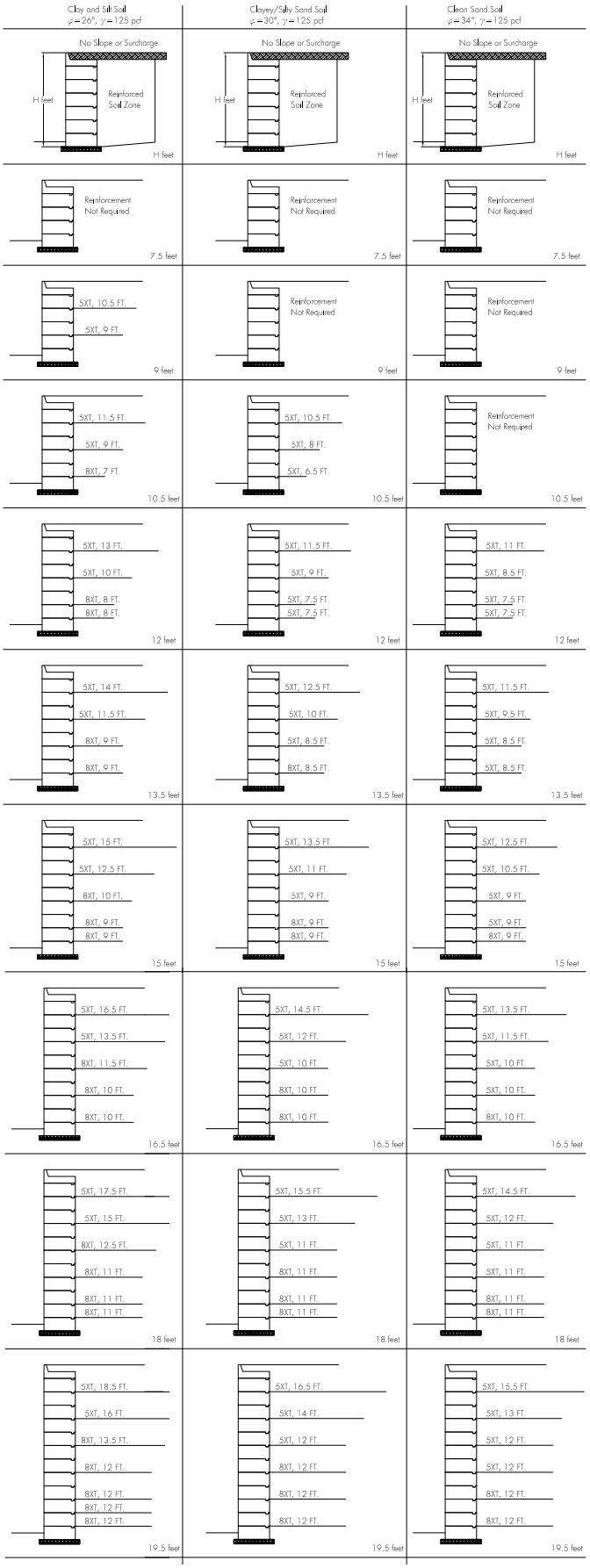


This product specification section contains diagrams for height, setback and geogrid details. Visit us online for a wide variety of product applications.
Online at: www.LondonBoulder.net



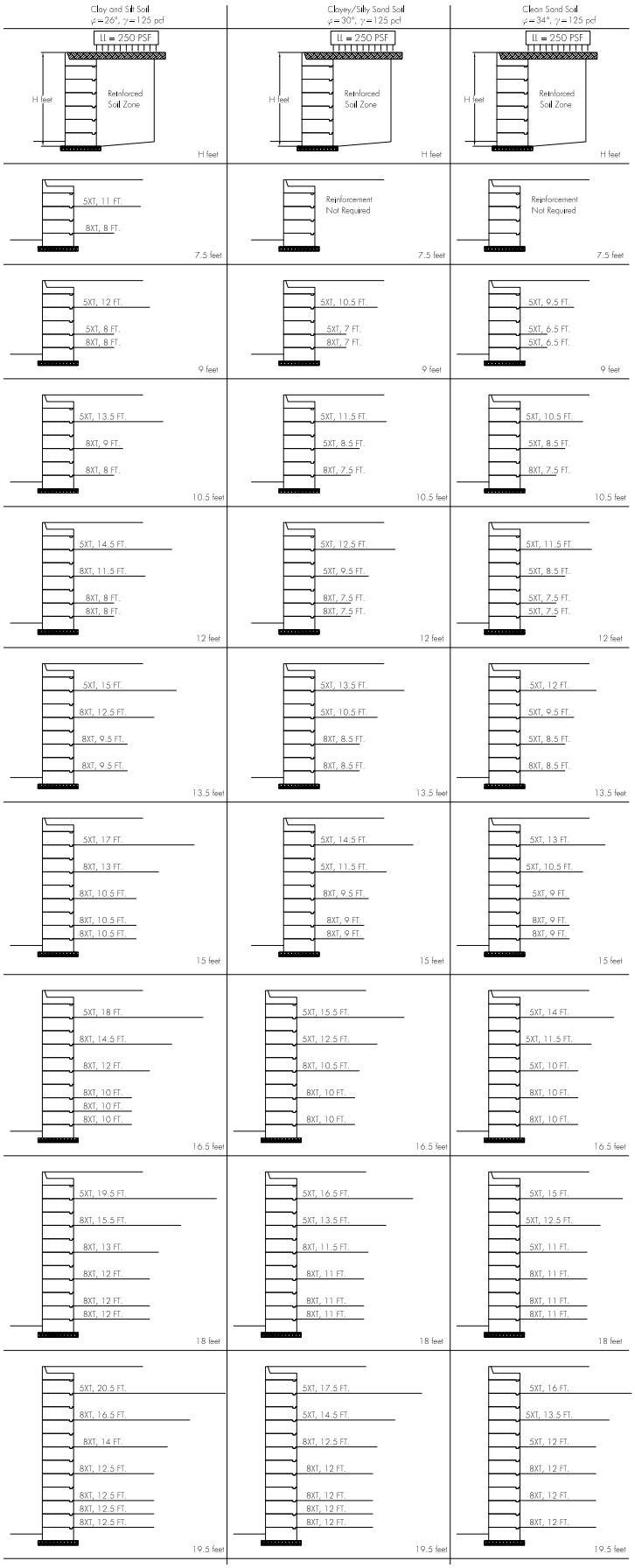
No Setback Units/No Slope or Surcharge

LondonBoulder Geosynthetic Reinforcement Estimating Charts



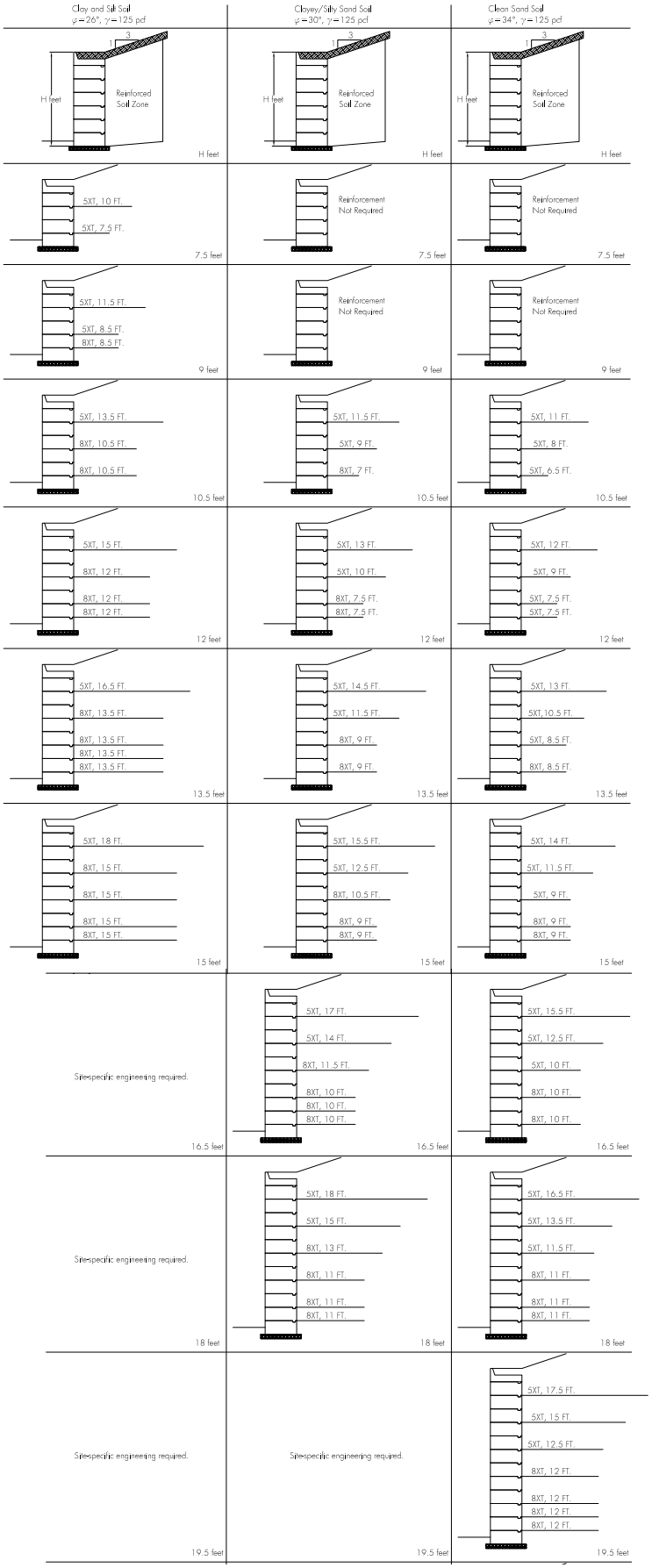
No Setback Units/250 psf Live Load

LondonBoulder Geosynthetic Reinforcement Estimating Charts



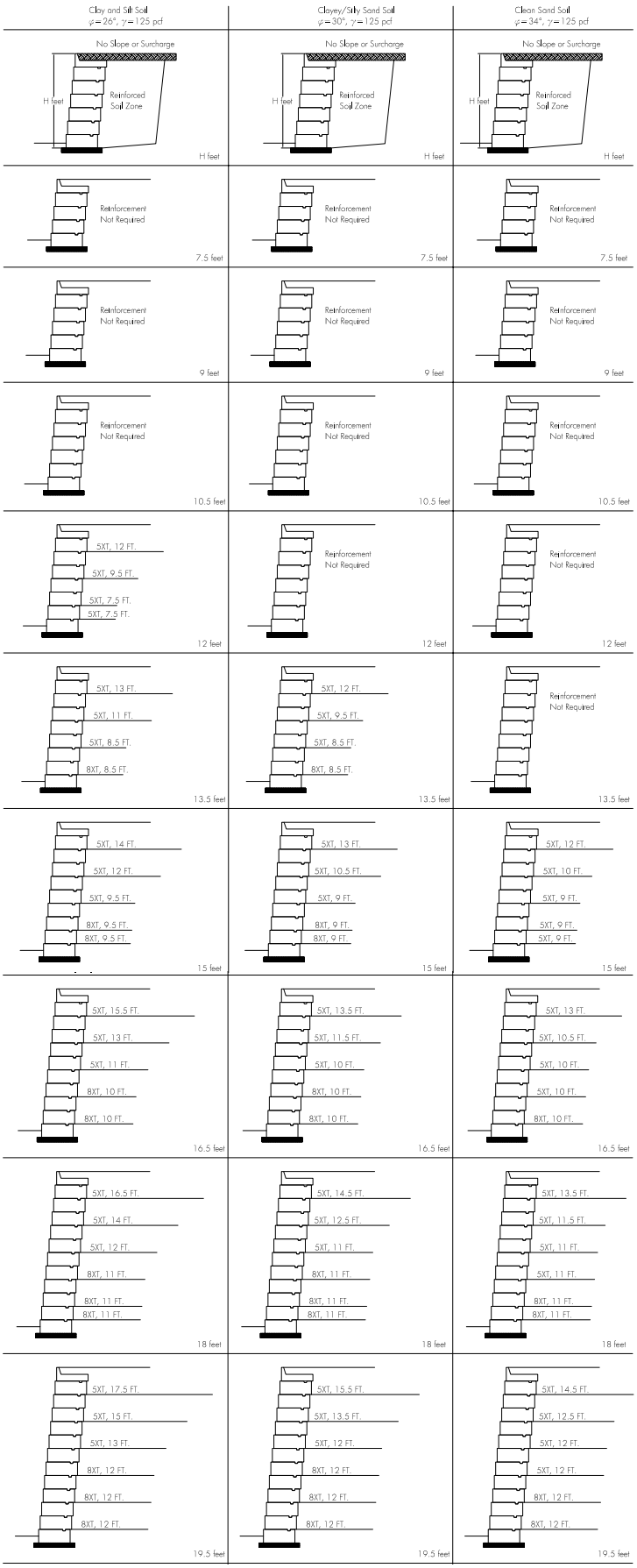
No Setback Units/3:1 Crest Slope

LondonBoulder Geosynthetic Reinforcement Estimating Charts



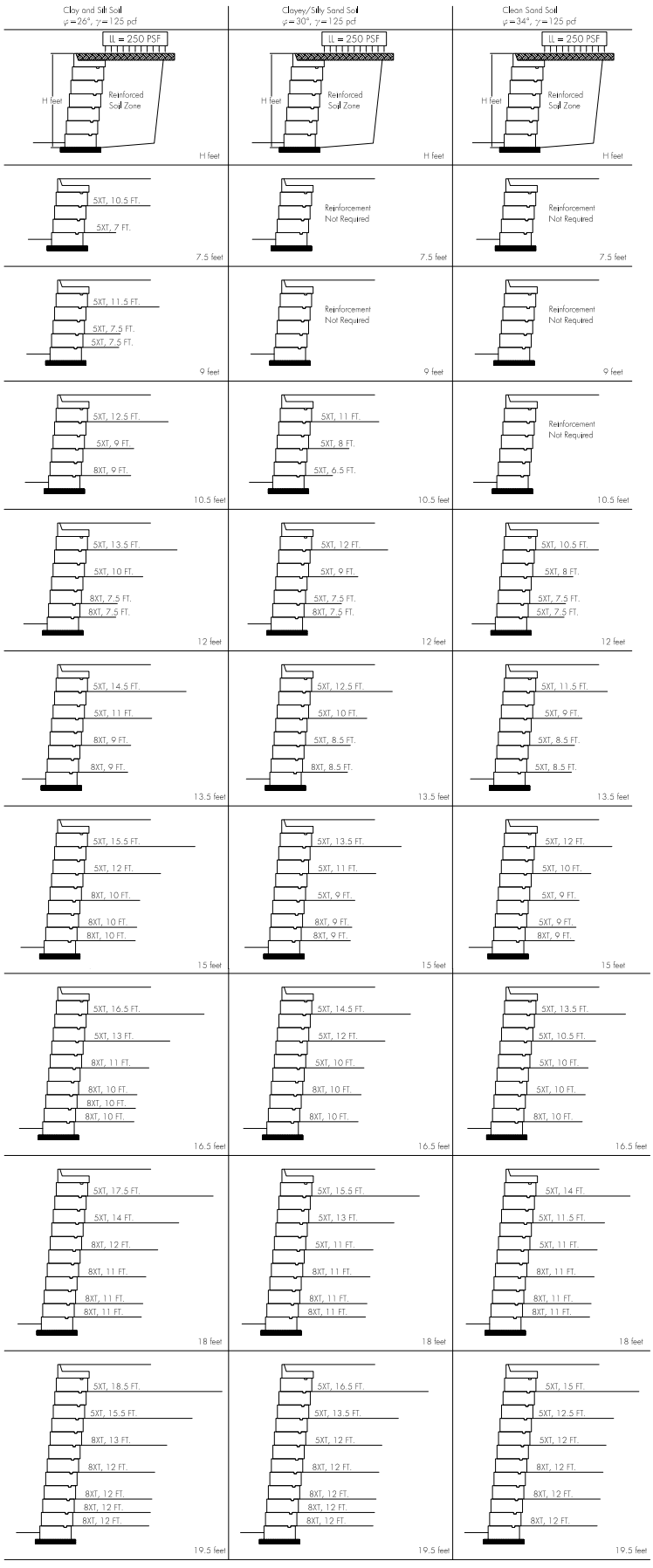
2-Inch Setback Units/No Slope or Surcharge

LondonBoulder Geosynthetic Reinforcement Estimating Charts



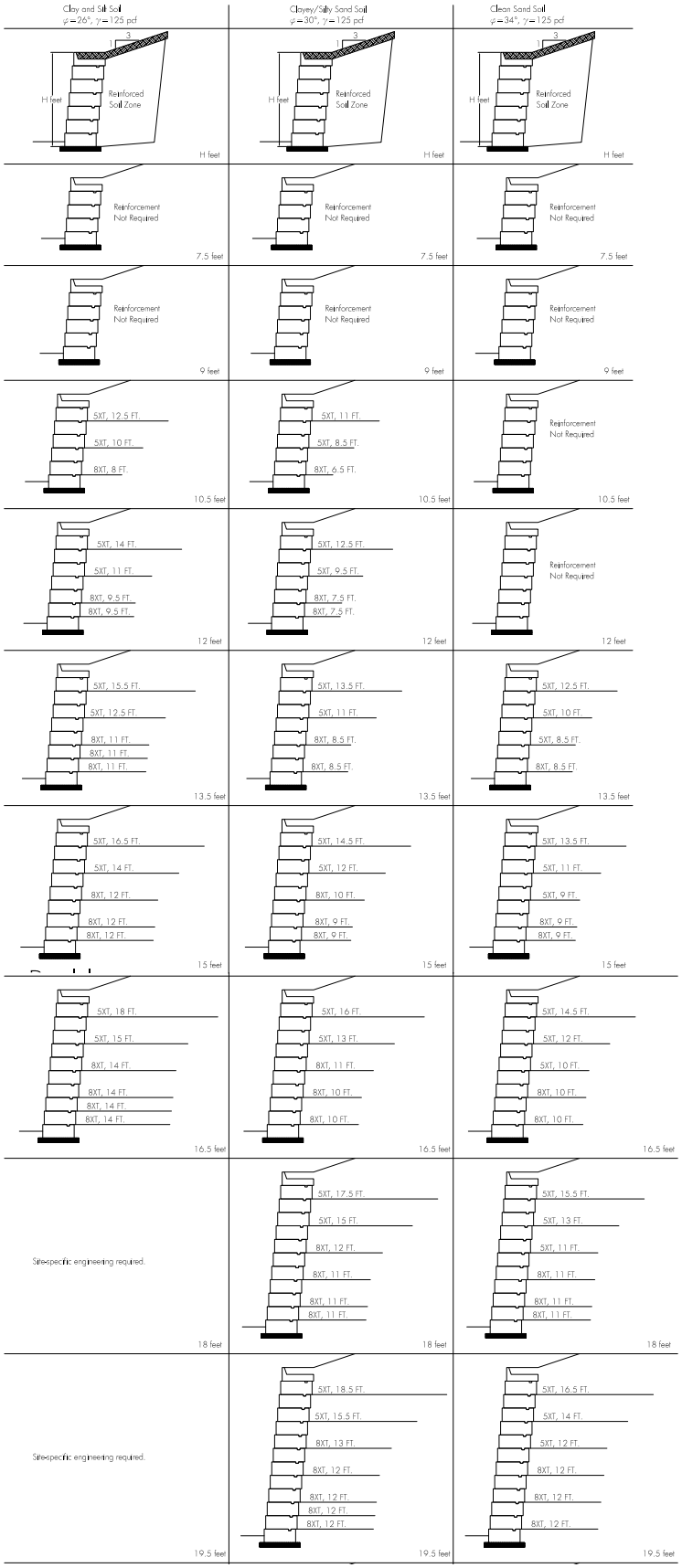
2-Inch Setback Units/250 psf Live Load

LondonBoulder Geosynthetic Reinforcement Estimating Charts



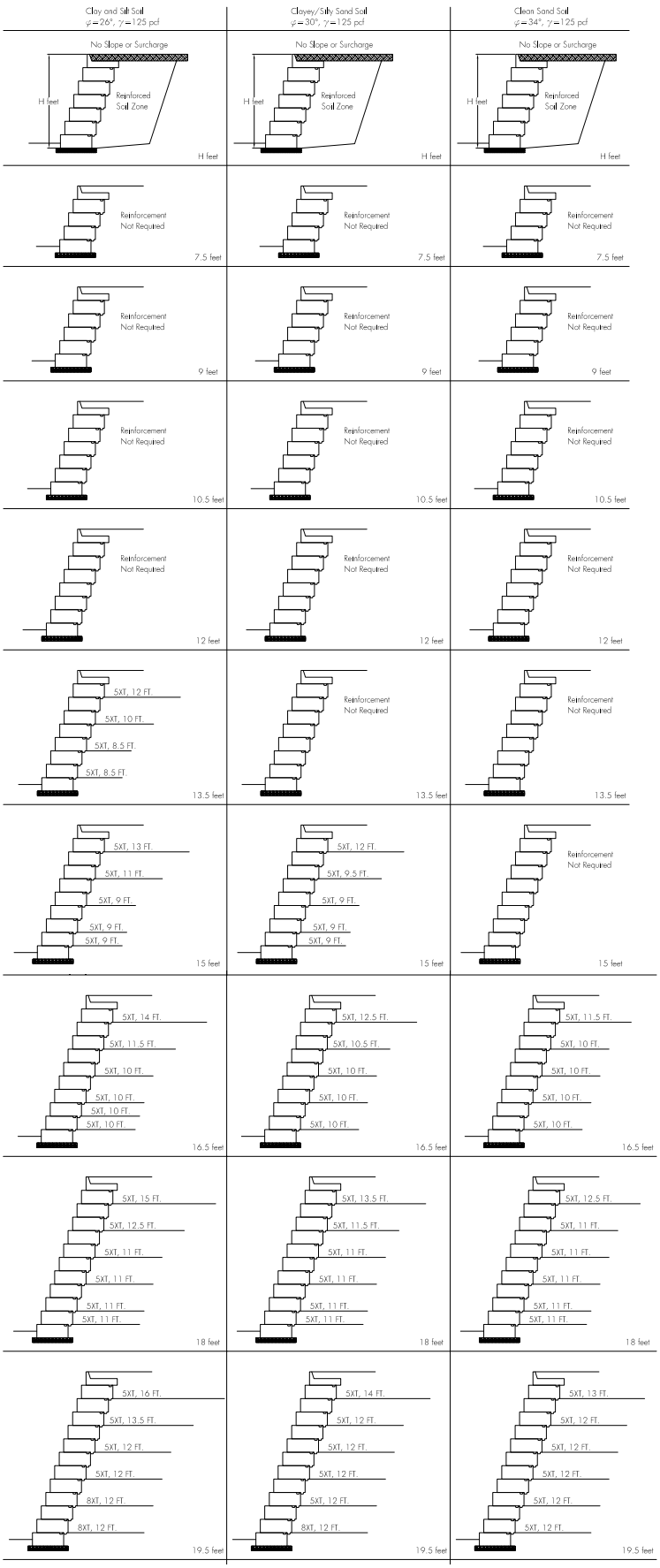
2-Inch Setback Units/3:1 Crest Slope

LondonBoulder Geosynthetic Reinforcement Estimating Charts



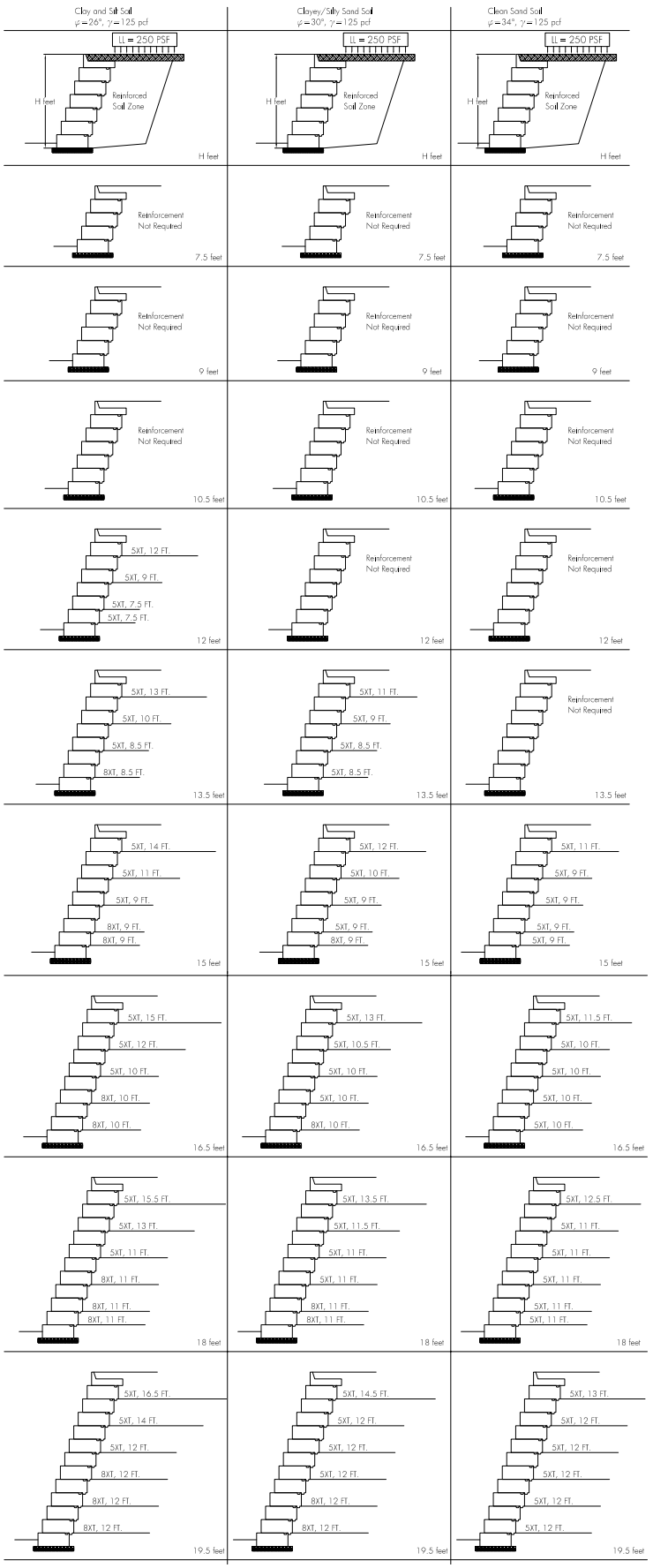
6-Inch Setback Units/No Slope or Surcharge

LondonBoulder Geosynthetic Reinforcement Estimating Charts

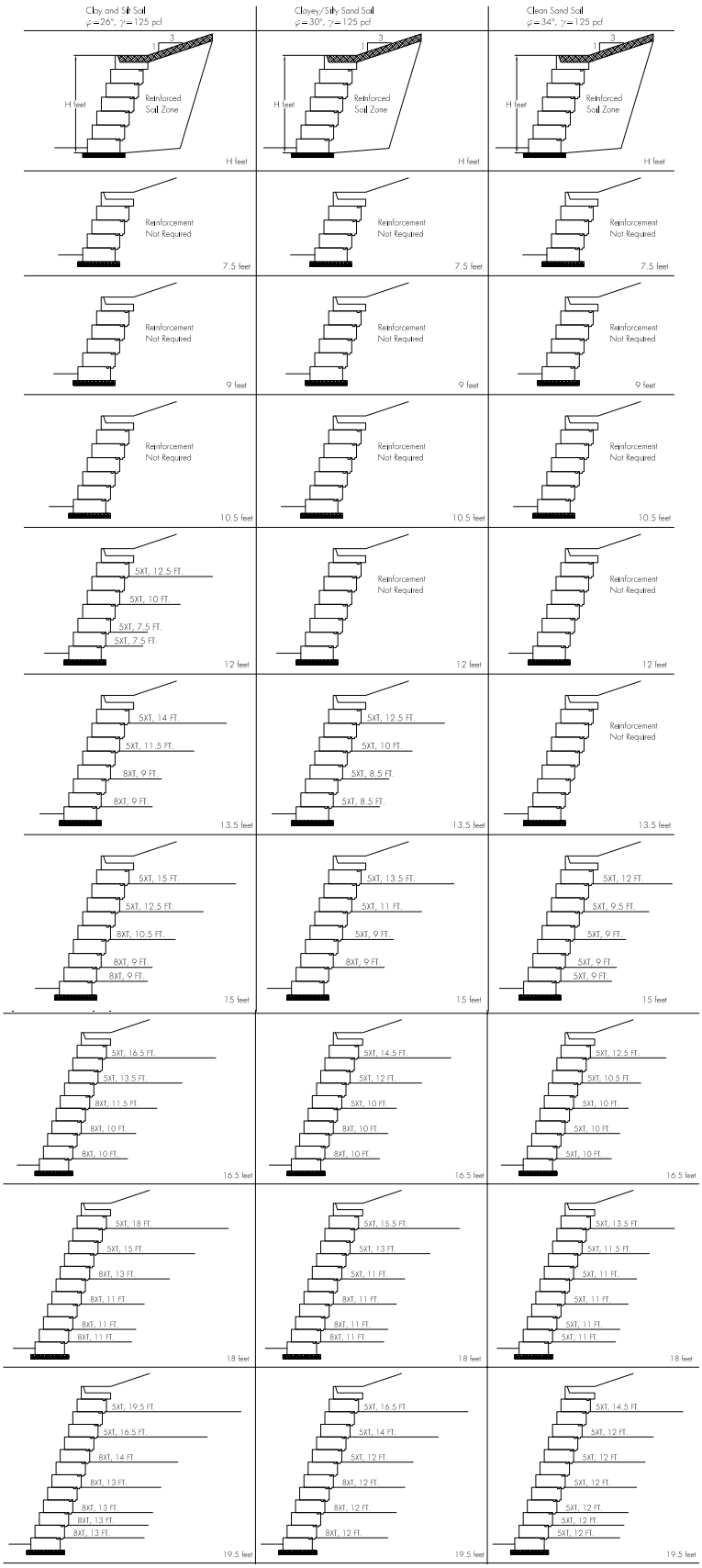


6-Inch Setback Units/250 psf Live Load

LondonBoulder Geosynthetic Reinforcement Estimating Charts



LondonBoulder Geosynthetic Reinforcement Estimating Charts



SECTION 32 32 23
CONCRETE SEGMENTAL RETAINING WALL SYSTEM
"BIG BLOCK" / "WETCAST"

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Retaining wall system constructed of wet-cast concrete segmental retaining wall units.
B. Geosynthetic reinforcement fabric
C. Leveling pad base
D. Drainage aggregate
E. Backfill
F. Drainage pipe
G. Adhesives

1.02 RELATED SECTIONS

Note to Specifier: Include Section 01270 only if Article 3.12 is included

A. Section 01270 - Unit Prices

Note to Specifier: Include Section 02300 below for finish grading, and/or add other paving or surfacing related Sections if required

B. Section 02300 - Earthwork: For finish grading.

1.02 REFERENCES

A. American Association of State Highway Transportation Officials (AASHTO)
1. AASHTO M288 Geotextile Specification for Highway Applications
2. AASHTO Standard Specifications for Highway Bridges

B. American Society for Testing and Materials (ASTM)
1. ASTM C94 Ready-Mixed Concrete [Last Update: 05]
2. ASTM C1372 Standard Specification for Segmental Retaining Wall Units [Last Update: 01a]
3. ASTM D448 Standard Classification for Sizes of Aggregate for Road and Bridge Construction [Last Update: 98]
4. ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/f^3)(600 kN-m/m^3) [Last Update: 00a]
5. ASTM D1556 Standard Test Method for Density and Unit Weight of Soil In Place by the Sand Cone Method [Last Update: 00]
6. ASTM D1557 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/f^3)(2700 kN-m/m^3) [Last Update: 00]
7. ASTM D2487 Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System) [Last Update: 00]
8. ASTM D2922 Standard Test Methods for Density of Soil and Soil-Aggregate In Place by Nuclear Methods (Shallow Depth) [Last Update: 01]
9. ASTM D3034 Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer pipe and Fittings [Last Update: 00]
10. ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils [Last Update: 00]
11. ASTM D4595 Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method [Last Update: 86 (2001)]
12. ASTM D5262 Standard Test Method for Evaluating the Unconfined Tension Creep Behavior of Geosynthetics [Last Update: 97]
13. ASTM F405 [Last Update: 97] Standard Specification for Corrugated Polyethylene (PE) Tubings and Fittings
14. ASTM G51 Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing [Last Update: 95 (2000)]

C. National Concrete Masonry Association (NCMA)
1. NCMA Design Manual For Segmental Retaining Walls, Second Edition, Second Printing (1997)
2. NCMA SRWU-1 Determination of Connection Strength Between Geosynthetics and Segmental Concrete Units
3. NCMA SRWU-2 Determination of Shear Strength Between Segmental Concrete Units

1.03 DEFINITIONS

A. LondonBoulder Retaining Wall Unit: “Wet-cast” concrete segmental block provided by authorized and licensed manufacturer.
B. Backfill: Soil which is used as fill behind the drainage aggregate, and within the reinforced soil mass (if applicable).
C. Drainage Aggregate: Material used between and directly behind the concrete retaining wall units.
D. Filter Fabric: Material used for separation and filtration of dissimilar soil types.
E. Foundation Soil: Soil mass supporting the leveling pad and reinforced soil zone of the retaining wall system.
F. Geosynthetic Reinforcement (Geogrid): Material specifically fabricated for use as a soil reinforcement.
G. Global Stability: The general mass movement of a soil reinforced segmental retaining wall structure and adjacent soil mass.
H. Project Geotechnical Engineer: A registered engineer employed by the Owner to perform site observations, provide recommendations for foundation support, and verify soil shear strength parameters.

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300:
1. Product Data: Material description and installation instructions for each manufactured product specified.
2. Shop Drawings: Retaining wall system design, including wall elevation views, geosynthetic reinforcement layout, pertinent details, and drainage provisions. The shop drawings shall be signed by a registered professional engineer licensed in the state of wall installation.
3. Design Calculations: Engineering design calculations prepared in accordance with the NCMA Design Manual For Segmental Retaining Walls, or the AASHTO Standard Specifications for Highway Bridges, Section 5.8 (1998) or AASHTO NHI-043 (2002) (whichever is applicable). Analysis of global stability must be addressed and incorporated into the shop drawings.
4. Samples
    a. Furnish one unit in the color and face pattern specified, if requested.
    b. Furnish 2 yard square or larger piece of the geosynthetic reinforcement specified.

1.05 DELIVERY, STORAGE AND HANDLING

A. Deliver, store, and handle materials in accordance with manufacturer’s recommendations, in such a manner as to prevent damage. Check the materials upon delivery to assure that proper material has been received. Store above ground on wood pallets or blocking. Remove damaged or otherwise unsuitable material, when so determined, from the site.
1. Exposed faces of concrete wall units shall be free of chips, cracks, stains, and other imperfections detracting from their appearance, when viewed from a distance of 10 feet.
2. Prevent mud, wet cement, adhesives and similar materials which may harm appearance of units, from coming in contact with system components.

1.06 EXTRA MATERIALS

A. Furnish Owner with 3 replacement units identical to those installed on the Project.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Concrete Retaining Wall Units: “LondonBoulder Retaining Wall Units” as manufactured under license and authorization from LondonBoulder and JME Companies.
1. Physical Requirements
    a. Meet requirements of ASTM C94 and ASTM 1372. Must have a 28-day compressive strength of no less than 4,300 psi, air entrainment of between 4.5% and 8%, and a 3 to 4 inch slump. Unit height dimensions shall not vary more than plus or minus 1/2 inch, not including textured face.
    b. Units produced by DOT certified plants.

Note to Specifier: In Subparagraph below, select appropriate entity who will determine color

b. Color: Wall can be left natural concrete color or stained after installation. If colored stain is desired, retaining wall shall be stained in accordance with Section 09 93 13 “Exterior Staining.” Acceptable stains include but are not limited to: TK Products TRI-SHEEN PIGMENTED STAIN TK-5272 and Sherwin Williams H & C SHIELD PLUS CONCRETE STAIN.
c. Sealing: [If desired, provide options here as specified in Section 099623 Graffiti Resistant Coatings or Section 099723 Concrete and Masonry Coatings.] Acceptable sealers include TK Products TK-290 WDOT TRI-SILOXANE.

Note to Specifier: In Subparagraph below, select face style

d. Face Pattern Geometry: [Chiseled Limestone] [Stacked Cobblestone].
e. Include an integral concrete shear connection flange/locator.

B. Geosynthetic Reinforcement: Polyester fiber geogrid or geotextile, or polypropylene woven geotextile, as shown on the Drawings.

C. Leveling Pad Base
1. Aggregate Base: Crushed stone or granular fill meeting the following gradation as determined in accordance with ASTM D448:

Sieve Size	Percent Passing
1 inch	100
No. 4	35 to 70
No. 40	10 to 35
No. 200	3 to 10

a. Base Thickness: 6 inches (minimum compacted thickness).

2. Concrete Base: Nonreinforced lean concrete base.
a. Compressive Strength: 500 psi (maximum).
b. Base Thickness: At least 2 inches, but not more than 3 inches.

D. Drainage Aggregate: Clean crushed stone or granular fill meeting the following gradation as determined in accordance with ASTM D448:

Sieve Size	Percent Passing
1 inch	100
3/4 inch	75 to 100
No. 4	0 to 60
No. 40	0 to 50
No. 200	0 to 5

E. Backfill: Soil free of organics and debris and consisting of either GP, GW, SP, SW, or SM type, classified in accordance with ASTM D2487 and the USCS classification system.
1. Soils classified as SC and CL are considered suitable soils for segmental retaining walls with a total height of less than 15 feet unless the Plasticity Index (PI) is 20 or more.
2. Maximum particle size for backfill is 2 inches.
3. Unsuitable soils are organic soils and those soils classified as CH, OH, MH, OL, or PT.

F. Impervious Material: Clayey soil or other similar material which will prevent percolation into the drainage zone behind the wall.
G. Drainage Pipe: Perforated or slotted PVC or corrugated HDPE pipe manufactured in accordance with D3034 and/or ASTM F405. The pipe may be covered with a geotextile filter fabric to function as a filter.
H. Construction Adhesive: Exterior grade adhesive as recommended by the retaining wall unit manufacturer.

PART 3 - EXECUTION

3.01 EXAMINATION

Note to Specifier: In Paragraph below, select appropriate entity

A. Examine the areas and conditions under which the retaining wall system is to be erected, and notify the [Architect] [Engineer] [Owner] [Contractor] in writing of conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.
B. Promptly notify the wall design engineer of site conditions which may affect wall performance, soil conditions observed other than those assumed, or other conditions that may require a reevaluation of the wall design.
C. Verify the location of existing structures and utilities prior to excavation.

3.02 PREPARATION

A. Ensure surrounding structures are protected from the effects of wall excavation.
B. Excavation support, if required, is the responsibility of the Contractor, including the stability of the excavation and it's influence on adjacent properties and structures.

3.03 EXCAVATION

Note to Specifier: In Paragraph below, select appropriate entity

A. Excavate to the lines and grades shown on the Drawings. Over-excavation not approved by the [Architect] [Engineer] [Owner (or Owner's representative)] will not be paid for by the Owner. Replacement of these soils with compacted fill and/or wall system components will be required at the Contractor's expense. Use care in excavating to prevent disturbance of the base beyond the lines shown.

3.04 FOUNDATION PREPARATION

A. Excavate foundation soil as required for footing or base dimension shown on the Drawings, or as directed by the Project geotechnical engineer.
B. The Project geotechnical engineer will examine foundation soil to ensure that the actual foundation soil strength meets or exceeds that indicated on the Drawings. Remove soil not meeting the required strength. Oversize resulting space sufficiently from the front of the block to the back of the reinforcement, and backfill with suitable compacted backfill soils.
C. The Project geotechnical engineer will determine if the foundation soils will require special treatment or correction to control total and differential settlement.
D. Fill over-excavated areas with suitable compacted backfill, as recommended by the Project geotechnical engineer.

3.05 BASE COURSE PREPARATION

A. Place base materials to the depths and widths shown on the Drawings, upon undisturbed soils, or foundation soils prepared in accordance with Article 3.04.
    1. Extend the leveling pad laterally at least 6 inches in front and behind the lowermost concrete retaining wall unit.
    2. Provide aggregate base compacted to 6 inches thick (minimum).
    3. The Contractor may at their option, provide a concrete leveling pad as specified in Subparagraph 2.01.C.2, in lieu of the aggregate base.
    4. Where a reinforced footing is required by local code official, place footing below frost depth.
B. Compact aggregate base material to provide a level, hard surface on which to place the first course of units.
C. Prepare base materials to ensure complete contact with retaining wall units. Gaps are not allowed.

3.06 ERECTION

A. General: Erect units in accordance with manufacturer's instructions and recommendations, and as specified herein.
B. Place first course of concrete wall units on the prepared base material. Check units for level and alignment. Maintain the same elevation at the top of each unit within each section of the base course.
C. Ensure that foundation units are in full contact with natural or compacted soil base.
D. Place concrete wall units side-by-side for full length of wall alignment. Alignment may be done by using a string line. Gaps are not allowed between the foundation concrete wall units.
E. Place 12 inches (minimum) of drainage aggregate between, and directly behind the concrete wall units. Provide a drainage zone behind the wall units to within 9 inches of the final grade. Cap the backfill and drainage aggregate zone with 9 inches of impervious material.
F. Install drainage pipe at the lowest elevation possible, to maintain gravity flow of water to outside of the reinforced zone. Slope the main collection drainage pipe, located just behind the concrete retaining wall units, 2 percent (minimum) to provide gravity flow to the daylighted areas. Daylight the main collection drainage pipe through the face of the wall, and/or to an appropriate location away from the wall system at each low point or at 50 foot (maximum) intervals along the wall. Alternately, the drainage pipe can be connected to a storm sewer system at 50 foot (maximum) intervals.
G. Remove excess fill from top of units and install next course. Ensure drainage aggregate and backfill are compacted before installation of next course.
H. Check each course for level and alignment. Adjust units as necessary to maintain level and alignment prior to proceeding with each additional course.
I. Install each succeeding course. Backfill as each course is completed. Pull the units forward until the locating surface of the unit contacts the locating surface of the units in the preceding course. Interlock wall segments that meet at corners by overlapping successive courses. Attach concrete retaining wall corner units.
J. Install geosynthetic reinforcement in accordance with geosynthetic manufacturer's recommendations and the shop drawings.
    1. Prior to geosynthetic reinforcement placement, place the backfill and compact to the elevation of the top of the wall units at the elevation of the geosynthetic reinforcement.
    2. Orient geosynthetic reinforcement with the highest strength axis perpendicular to the wall face.
    3. Place geosynthetic reinforcement at the elevations and to the lengths shown on the Drawings.
    4. Lay geosynthetic reinforcement horizontally on top of the concrete retaining wall units and the compacted backfill soils. Place the geosynthetic reinforcement within one inch of the face of the concrete retaining wall units. Place the next course of concrete retaining wall units on top of the geosynthetic reinforcement.
    5. The geosynthetic reinforcement shall be in tension and free from wrinkles prior to placement of the backfill soils. Pull geosynthetic reinforcement hand-taut and secure in place with staples, stakes, or by hand-tensioning until the geosynthetic reinforcement is covered by 6 inches of loose fill.
    6. The geosynthetic reinforcements shall be continuous throughout their embedment lengths. Splices in the geosynthetic reinforcement strength direction are not allowed.
    7. Do not operate tracked construction equipment directly on the geosynthetic reinforcement.
    At least 6 inches of compacted backfill soil is required prior to operation of tracked vehicles over the geosynthetic reinforcement.
    Keep turning of tracked construction equipment to a minimum.
    8. Rubber-tired equipment may pass over the geosynthetic reinforcement at speeds of less than
    5 miles per hour. Turning of rubber-tired equipment is not allowed on the geosynthetic reinforcement.

3.07 BACKFILL PLACEMENT

A. Place reinforced backfill, spread and compact in a manner that will minimize slack in the reinforcement.
B. Place fill within the reinforced zone and compact in lifts not exceeding 6 to 8 inches (loose thickness) where hand-operated compaction equipment is used, and not exceeding 12 inches (loose thickness) where heavy, self-propelled compaction equipment is used.
   1. Only lightweight hand-operated compaction equipment is allowed within 4 feet of the back of the retaining wall units. If the specified compaction cannot be achieved within 4 feet of the back of the retaining wall units, replace the reinforced soil in this zone with drainage aggregate material.

Note to Specifier: In Paragraph below, select revised modified Proctor densities if necessary, in lieu of standard Proctor densities specified

C. Minimum Compaction Requirements for Fill Placed in the Reinforced Zone
   1. Walls Less Than 15 Feet High: Compact to 95 percent of the soil's standard Proctor maximum dry density (ASTM D698) [modified Proctor maximum dry density (ASTM D1557)] for the entire wall height
   2. Walls 15 Feet High BUT NOT MORE THAN 30 Feet High: Change compaction requirements to 98 percent of the soil's standard Proctor maximum dry density (ASTM D698) [modified Proctor maximum dry density (ASTM D1557)] for depths below 15 feet.
   3. Walls Over 30 Feet High: Change compaction requirements to 100 percent of the soil's standard Proctor maximum dry density (ASTM D698) [modified Proctor maximum dry density (ASTM D1557)] for depths below 30 feet.
   4. Increase compaction requirements for retaining walls with slope heights at the back of the reinforced soil zone greater than 5 feet above the top of wall. Verify compaction requirements with Project geotechnical engineer.
   5. Utility Trench Backfill: Compact utility trench backfill in or below the reinforced soil zone to 98 percent of the soil's standard Proctor maximum dry density (ASTM D698) [modified Proctor maximum dry density (ASTM D1557)], or as recommended by the Project geotechnical engineer. If the height from the utility to finish grade is higher than 30 feet, increase compaction to 100 percent of the standard Proctor density [modified Proctor density].
      a. Utilities must be properly designed (by others) to withstand all forces from the retaining wall units, reinforced soil mass, and surcharge loads, if any.

   6. Moisture Content: Within 2 percentage points of the optimum moisture content for all wall heights.
   7. These specifications may be changed based on recommendations by the Project geotechnical engineer.
      a. If changes are required, the Contract Sum will be adjusted by written Change Order.

D. At the end of each day's operation, slope the last level of compacted backfill away from the interior (concealed) face of the wall to direct surface water runoff away from the wall face.
   1. The General Contractor is responsible for ensuring that the finished site drainage is directed away from the retaining wall system.
   2. In addition, the General Contractor is responsible for ensuring that surface water runoff from adjacent construction areas is not allowed to enter the retaining wall area of the construction site.

E. Refer to Article 3.10 for compaction testing.

3.08 CAP UNIT INSTALLATION

A. Apply adhesive to the top surface of the unit below and place the cap unit into desired position.
B. Cut cap units as necessary to obtain the proper fit.
C. Backfill and compact to top of cap unit.

3.09 SITE CONSTRUCTION TOLERANCES

A. Site Construction Tolerances
   1. Vertical Alignment: Plus or minus 1.5 inches over any 10-foot distance, with a maximum differential of 3 inches over the length of the wall.
   2. Horizontal Location Control From Grading Plan
      a. Straight Lines: Plus or minus 1.5 inches over any 10-foot distance.
      b. Corner and Radius Locations: Plus or minus 12 inches.
      c. Curves and Serpentine Radii: Plus or minus 2 feet.

   3. Immediate Post Construction Wall Batter: Within 2 degrees of the design batter of the concrete retaining wall units.
   4. Bulging: Plus or minus 1.25 inches over any 10-foot distance.

3.10 FIELD QUALITY CONTROL

A. Installer is responsible for quality control of installation of system components. Employ a qualified independent third party to verify the correct installation of system components in accordance with these specifications and the Drawings.
B. The Owner, at their expense, will retain a qualified professional to perform quality assurance checks of the installer's work.
C. Correct work which does not meet these specifications or the requirements shown on the Drawings at the installer's expense.
D. Perform compaction testing of the reinforced backfill placed and compacted in the reinforced backfill zone.
   1. Testing Frequency
      a. One test for every 2 feet (vertical) of fill placed and compacted, for every 50 lineal feet of retaining wall.
      b. Vary compaction test locations to cover the entire area of the reinforced soil zone, including the area compacted by the hand-operated compaction equipment.

3.11 ADJUSTING AND CLEANING

A. Replace damaged units with new units as the work progresses.
B. Remove debris caused by wall construction and leave adjacent paved areas broom clean.

Note to Specifier: Include Article 3.12 ONLY for municipal work when required

3.12 MEASUREMENT AND PAYMENT

A. Measurement of segmental retaining wall shall be on an installed square foot basis computed on the total face area of wall installed. Wall face area includes the bottom of the base course to the top of the wall, and the entire length of the wall.
B. Payment for the wall will be made on a square foot basis at the agreed upon Contract Unit Price.
1. Payment should be considered full compensation for labor, materials, equipment and testing required to install the wall in accordance with these specifications and the Drawings.
2. Quantities may vary from that shown on the Drawings depending on existing topography. Change to the total quantity of wall face area will be paid or withheld at the agreed upon Contract Unit Price.

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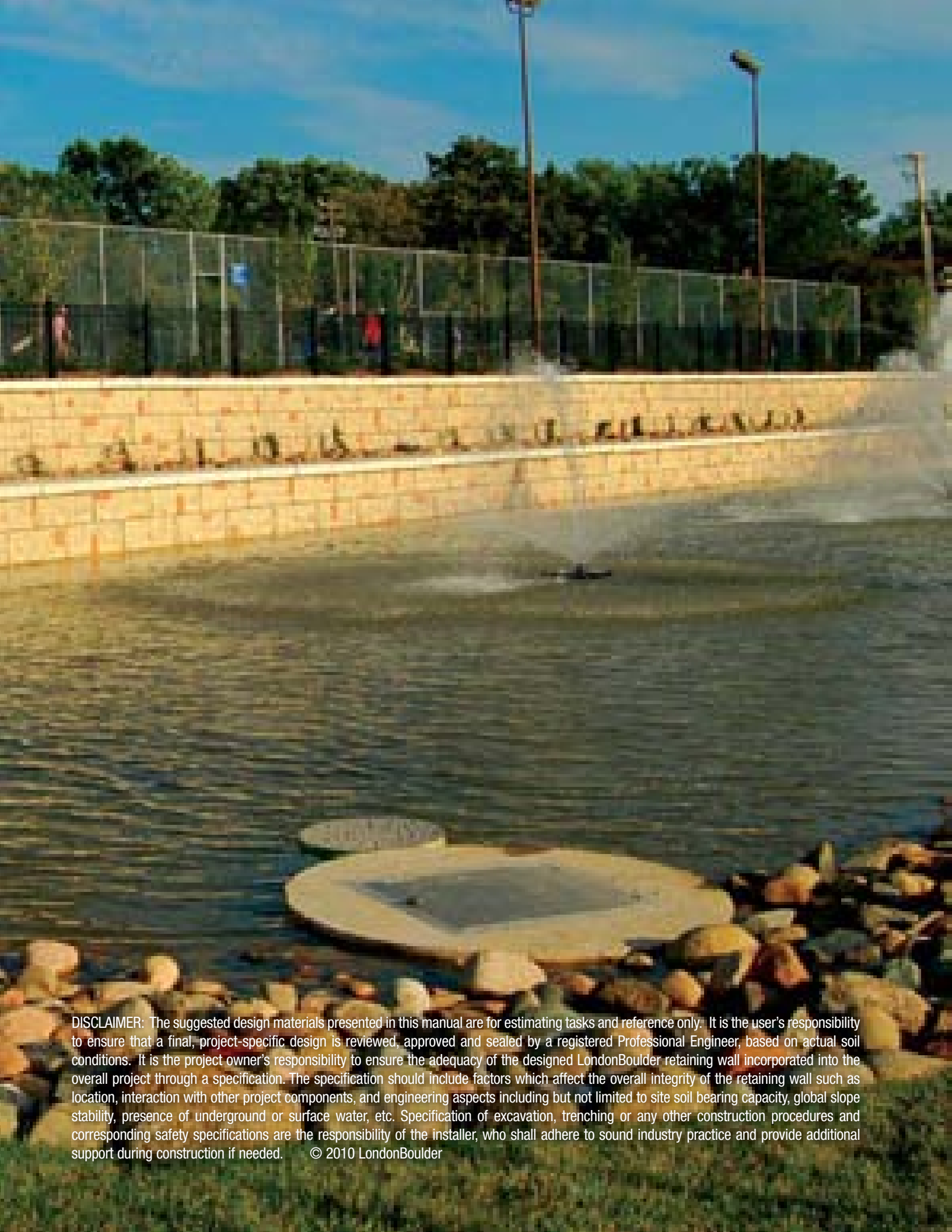

DISCLAIMER: The suggested design materials presented in this manual are for estimating tasks and reference only. It is the user's responsibility to ensure that a final, project-specific design is reviewed, approved and sealed by a registered Professional Engineer, based on actual soil conditions. It is the project owner's responsibility to ensure the adequacy of the designed LondonBoulder retaining wall incorporated into the overall project through a specification. The specification should include factors which affect the overall integrity of the retaining wall such as location, interaction with other project components, and engineering aspects including but not limited to site soil bearing capacity, global slope stability, presence of underground or surface water, etc. Specification of excavation, trenching or any other construction procedures and corresponding safety specifications are the responsibility of the installer, who shall adhere to sound industry practice and provide additional support during construction if needed.