SOIL RETENTION
PRODUCTS INC.

VERDURA® RETAINING WALL STANDARD DESIGN

For exposed wall heights of 3.0 to 7 feet
ICC-ES Legacy Report ER-5515

Prepared by

Soil Retention Designs, Inc.

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Carlsbad, CA 92008

The Verdura® Wall

The Verdura® Wall by Soil Retention Products, Inc of Carlsbad, California can be constructed as a gravity retaining structure or a geosynthetic reinforced segmental retaining wall, depending on the desired height. This Standard Design report addresses the use of our Verdura® 30 blocks and Posi-Dura® geosynthetic reinforcement for single-tier walls with exposed heights of 3.0 to 7.0 feet with a level ground surface in front of the wall. Walls with exposed heights of 3.0 feet or less may be constructed with either Verdura® 10 or Verdura® 30 blocks without the use of geosynthetic reinforcement or this design manual. In most municipalities, building permits and engineered designs are typically not needed for walls with exposed heights of 3.0 feet or less, and with no additional surcharge loading (**check with your local building department**). Walls with exposed heights greater than 3.0 feet must be constructed with Verdura® 30 blocks and Posi-Dura® geosynthetic reinforcement; refer to figure 1 and figure 2 for more information on your specific application. This design manual should not be used for walls with exposed heights greater than 7.0 feet. Walls with exposed heights greater than 7.0 feet should be designed for specific site conditions by a qualified geotechnical engineer. Walls with a descending slope at the bottom (see figure 3) or tiered walls may not conform to this standard design; these type of walls need to be evaluated by a geotechnical engineer for global stability prior to beginning construction. If you have questions about your wall, please contact Soil Retention Systems, Inc. for more information.

The Verdura® retaining wall system acts as an earthen buttress to resist lateral soil forces. Conventional retaining walls (typically constructed as reinforced concrete cantilever type structures) must resist all lateral forces by applying loads through rigid, poured-in-place, concrete foundations. Concrete foundations are not required with the Verdura® 30 retaining wall system. However, a gravel leveling pad can be used when the underlying soils consist of lower strength soils or soils that are difficult to level. The Verdura® retaining wall system has been approved by the ICC evaluation service in Legacy Report No. ER-5515.

The construction sequence of the Verdura® 30 retaining wall system allows block and geosynthetic reinforcement placement to be installed concurrently with the backfill operation. For installation information, please refer to the Scale New Heights brochure available at www.soilretention.com/verdura-dyi.html. With the Verdura® system there is no waiting time for concrete and / or masonry to cure, thus allowing for a

much quicker installation process. The stacked Verdura® 30 block facade has been designed to allow for planting of the wall face in the gap between the blocks. A planted wall is not only more aesthetically pleasing, but is essentially "graffiti-proof".

The open nature of the Verdura® 30 wall face prevents the possibility of hydrostatic pressure build-up behind the wall due to trapped water and prevents the possibility of ugly salt marks on the face. Conventional retaining walls or other retaining wall systems must be waterproofed and provided with an extensive drainage system in order to prevent the build-up of hydrostatic pressure behind the wall. Without adequate waterproofing and drainage, the trapped water will seep out through the face of the wall causing unsightly salt deposits on the face of the wall as the water evaporates. In addition to these unwanted aesthetic features, trapped water behind the wall could lead to a structurally unstable system that could result in failure of the wall.

The Verdura® 30 retaining wall construction methods allow for great flexibility in alignment or placement along both horizontal and vertical curves. These techniques avoid costly foundation stepping and complicated steel reinforcement. The Verdura® 30 retaining walls can also be constructed in a tiered configuration to allow larger landscaping configurations. Prior to beginning construction a qualified geotechnical engineer should be consulted to verify the global stability of the tiered wall system and to verify that this Standard Design is still applicable.

Proper planning of the Verdura® 30 wall is imperative to a successful project. Planning will allow you to determine accurate cost and time estimates for the wall construction. The planning process should include the following steps:

- Determination of site geometry, maximum height, and calculation of wall face square footage. Refer to following design check list for the square footage calculations.

- Preparation of site and wall plans. **Check with your local building department to determine the extent to which you can build your walls**. They may have some special requirements that you will need to meet.

- Obtain any necessary permits from your local building authority.

- Classification of site soils by a qualified geotechnical engineer.

- Design of wall based on this Standard Design manual or by a qualified engineer. If walls are tiered or placed on a slope (see figure 3) a geotechnical engineer should be consulted to perform a global stability analysis prior to construction.

- Create a materials list for blocks, Posi-Dura® geosynthetic reinforcement, drainage rock and pipe, and filter fabric.

- Retention of a qualified engineer to perform soil compaction testing and inspection services during wall construction.

Design Checklist

1. Wall Height

Based on the proposed location of the retaining wall, determine the desired exposed height and the total height.

Exposed Height (H') =_____ feet

+

Embedment (H_{emb}) =_____ feet

(The required embedment for all walls with exposed heights greater than 3.0 feet is 1 foot).

=

Total Height (H) = feet

2. If the exposed wall height is greater than 3.0 feet, a building permit is likely required. A building permit may be required for lower heights as well. **Check with your local building department.**

3. Determine soil type in accordance with Table 1804.2 of the 2007 California Building Code. Excerpts from the 2007 California Building Code are attached. Soils to be used in the Posi-Dura® geosynthetic reinforced zone should consist of Class 3, 4, or better. Class 5 soils (clays and silts) are allowed in the retained zone (behind the Posi-Dura® geosynthetic reinforced zone) only. **Class 5 soils may <u>not</u> be used in the Posi-Dura® geosynthetic reinforced zone.** When more than one soil type is involved, the more conservative (higher Class number) shall govern. See figure 1 for details showing where the specified soil zones are located.

4. Determine the type of wall based on the geometry of the cross section and any surcharge loading conditions in accordance with figure 1. Note that these designs are only good for a level bottom of wall condition as depicted in figure 1. **Walls with descending slopes at the bottom of wall location, as per figure 3 should be evaluated by a qualified geotechnical engineer.** This standard design may not apply to walls with descending slopes below.

5. Use appropriate design table to determine necessary spacing and length of Posi-Dura® reinforcement. Refer to figure 2 for the Posi-Dura® connection detail.

Posi-Dura® Installation Guidelines

The construction of the Verdura® 30 Retaining Wall with Posi-Dura® reinforcement is the same as the method presented in the Verdura® scale new heights brochure. The following guidelines are intended as a supplement to the Verdura® Scale New Heights brochure when using the standard designs in this manual. Visit www.soilretention.com for complete calculations and to download a Verdura® Scale New Heights brochure, or give us a call at (800) 346-7995, and we will send a brochure out to you.

1. Determine the required spacing of the Posi-Dura® Reinforcement. In general, Posi-Dura® reinforcement layers will be installed in every third course of blocks as depicted in figure 1. Near the top of the wall, a maximum of four Verdura® 30 block courses may be placed above the last (or highest) reinforcement layer.

2. Each Verdura® 30 block in a reinforced course shall receive a Posi-Dura® Reinforcement strip. When the blocks are spaced 9” apart one Posi-Dura reinforcement strip will be required every 2.25’ of the wall length. The length of the Posi-Dura® Reinforcement is determined by the appropriate design table for your site conditions and may be measured, cut, and installed as indicated in case 1, case 2, case 3, and figure 2.

3. 1 inch diameter schedule 80 PVC pipe shall be used to anchor the Posi-Dura® reinforcement to the Verdura® 30 block. The pipe is simply inserted through the sleeve on the Posi-Dura® reinforcement and placed in the recess of the block between gussets prior to backfilling. Refer to figure 2 for more information on the connection.

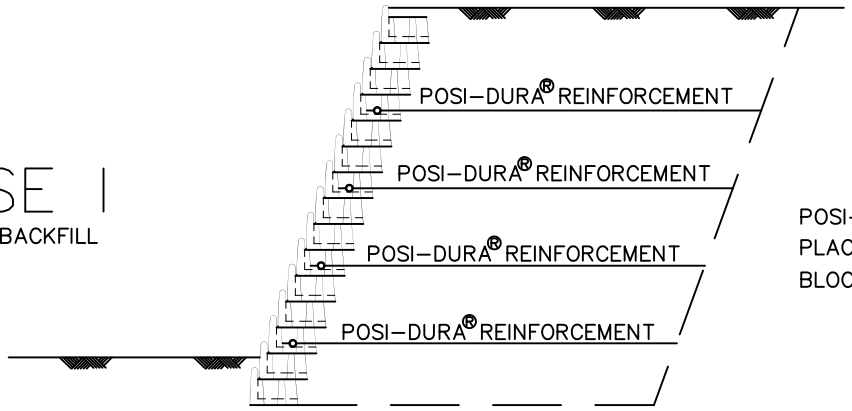
4. An additional 1 inch diameter schedule 80 PVC pipe shall be used to provide anchorage capacity for all Posi-Dura® reinforcement strips within the upper 2 feet of compacted fill soils. This pipe is inserted through the rear sleeve on the Posi-Dura® Reinforcement strip and surrounded with compacted fill soils near the backcut.

5. Posi-Dura® reinforcement layers should have a uniform length for each section of wall with a fixed height.

6. Opposite end of geosynthetic may be staked in place or held taut until backfill soils are placed on top of Posi-Dura® Reinforcement strips.

CASE I

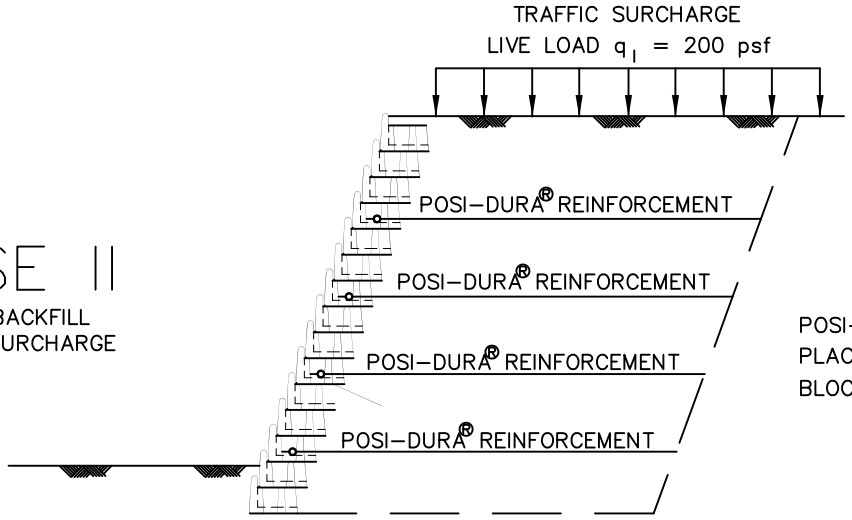
LEVEL BACKFILL



POSI–DURA® REINFORCEMENTS PLACED AT EVERY THIRD VERDURA BLOCK COURSE

CASE II

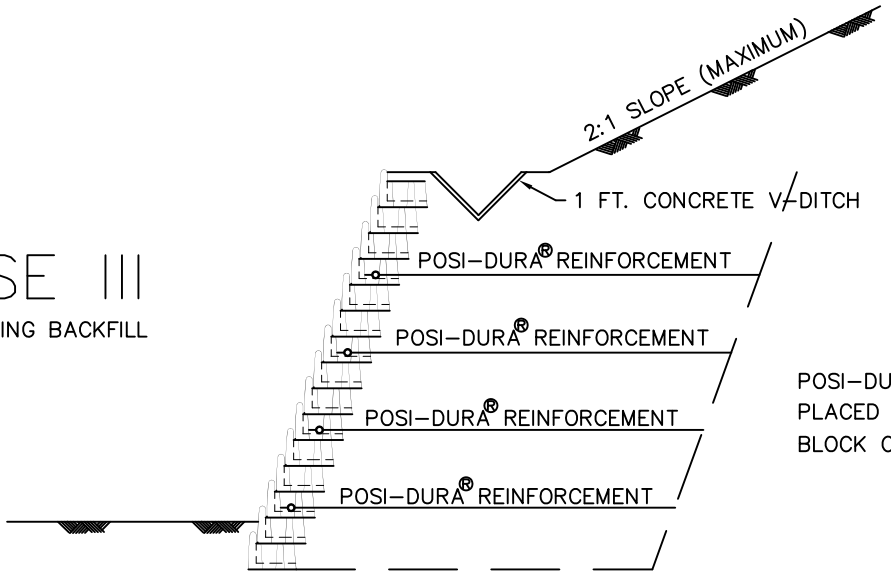
LEVEL BACKFILL
TRAFFIC SURCHARGE



POSI–DURA® REINFORCEMENTS PLACED AT EVERY THIRD VERDURA BLOCK COURSE

CASE III

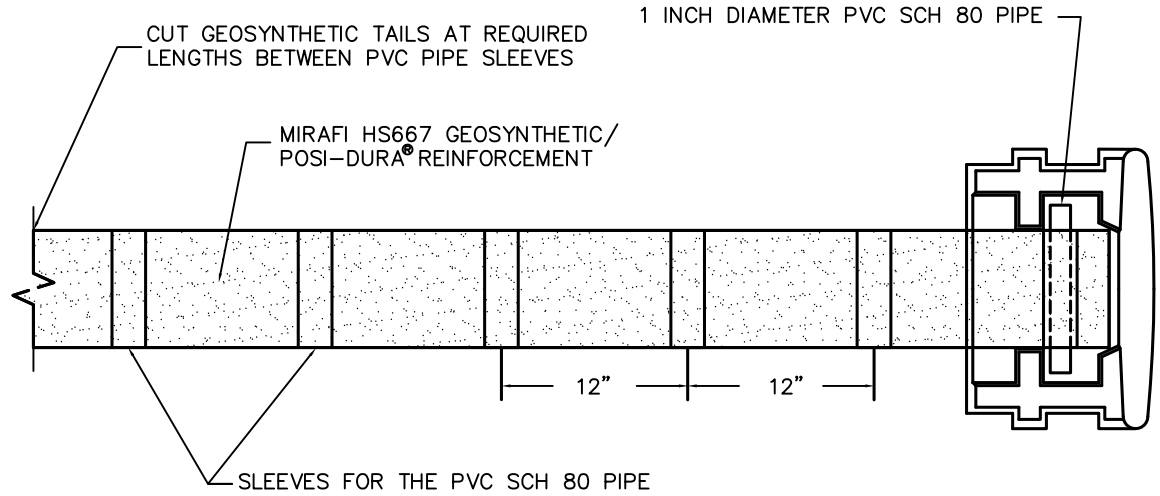
2:1 SLOPING BACKFILL

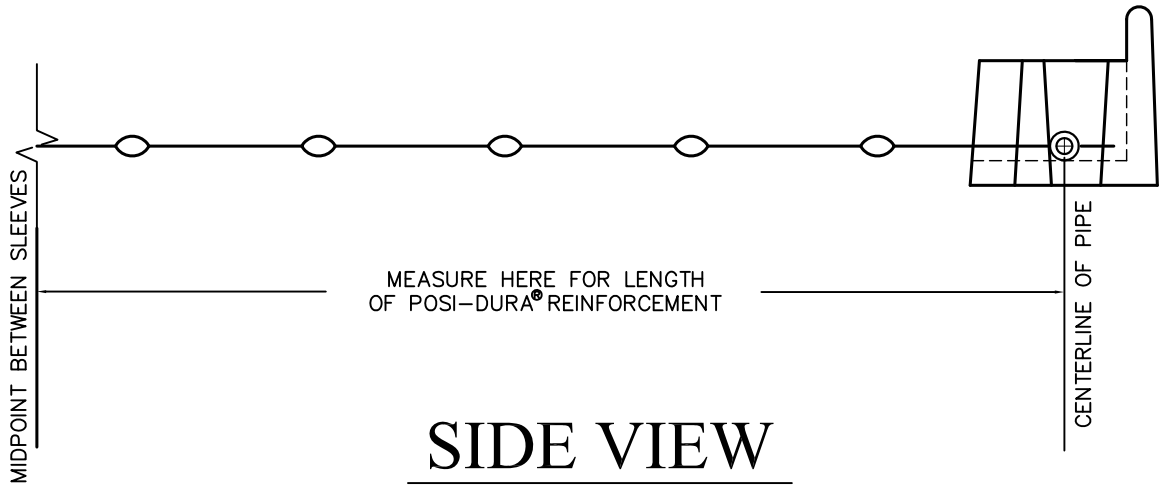


POSI–DURA® REINFORCEMENTS PLACED AT EVERY THIRD VERDURA BLOCK COURSE

FIGURE 1

PLAN VIEW





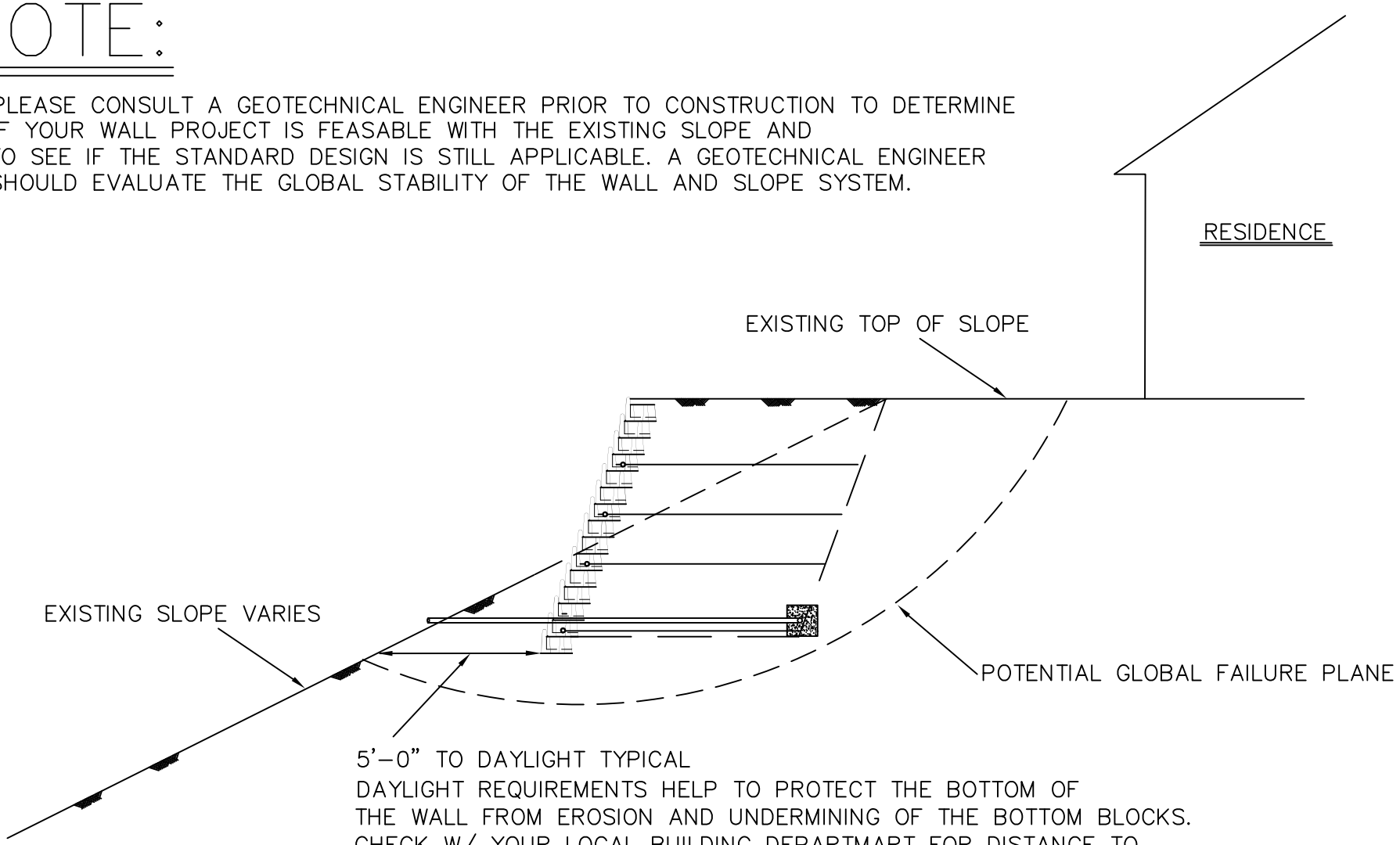
SIDE VIEW

POSI-DURA® REINFORCEMENT DETAIL

FIGURE 2

NOTE:

PLEASE CONSULT A GEOTECHNICAL ENGINEER PRIOR TO CONSTRUCTION TO DETERMINE IF YOUR WALL PROJECT IS FEASABLE WITH THE EXISTING SLOPE AND TO SEE IF THE STANDARD DESIGN IS STILL APPLICABLE. A GEOTECHNICAL ENGINEER SHOULD EVALUATE THE GLOBAL STABILITY OF THE WALL AND SLOPE SYSTEM.



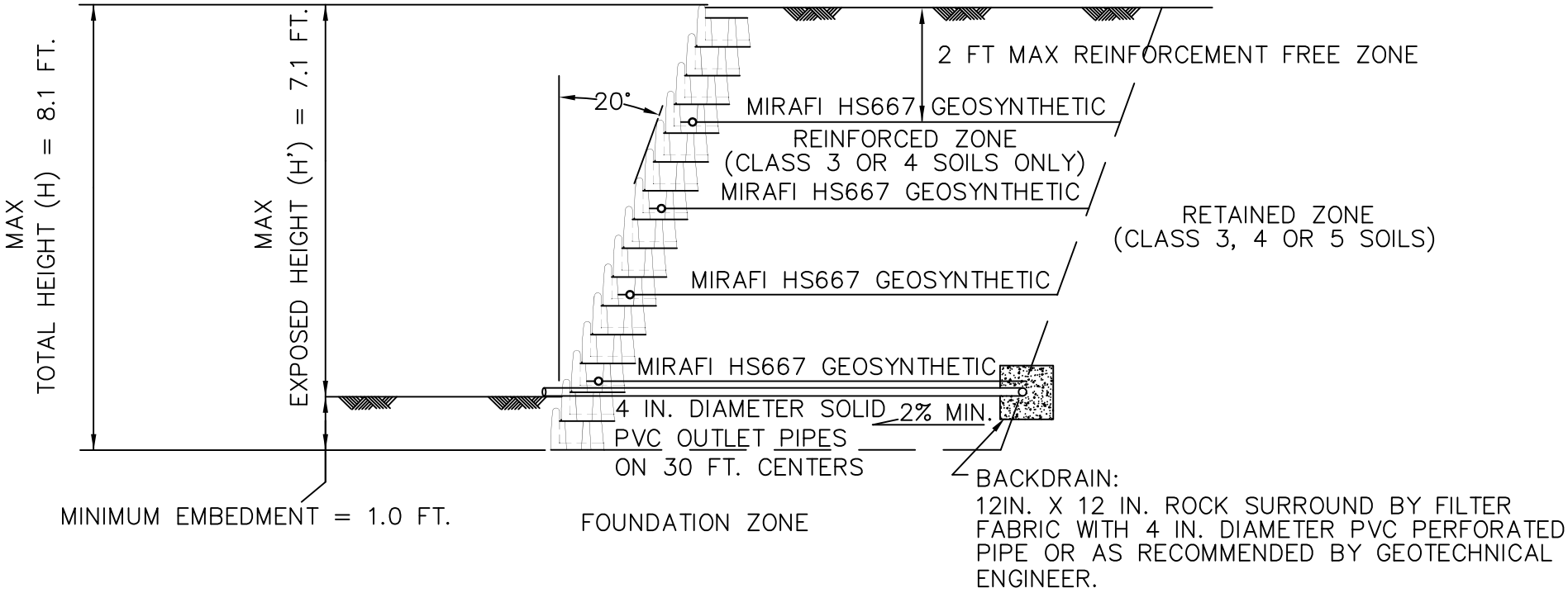
VERDURA WALL W/ A VARYING SLOPE BELOW

NOT TO SCALE

FIGURE 3

CASE I

CLASS OF SOIL per Table 1804.2 of the 2007 CBC	TOTAL WALL HEIGHT (H) (feet) INCLUDING EMBEDMENT	EXPOSED WALL HEIGHT (H') (feet)	EMBEDMENT DEPTH (H_{emb}) (feet)	NUMBER OF POSI-DURA® LAYERS	LENGTH OF POSI-DURA® REINFORCEMENT (feet)
3 GWandGP	4.3 to 5.0	3.3 to 4.0	1.0	2	3.5
	5.0 to 6.0	4.0 to 5.0	1.0	3	4.5
	6.0 to 7.0	5.0 to 6.0	1.0	3	4.5
	7.0 to 8.0	6.0 to 7.0	1.0	4	5.5
4 SW, SP, SM, SC, GM, and GC	4.3 to 5.0	3.3 to 4.0	1.0	2	3.5
	5.0 to 6.0	4.0 to 5.0	1.0	3	4.5
	6.0 to 7.0	5.0 to 6.0	1.0	3	5.5
	7.0 to 8.0	6.0 to 7.0	1.0	4	6.5
5 CL, ML, MH, and CH	4.3 to 5.0	3.3 to 4.0	1.0	2	3.5
	5.0 to 6.0	4.0 to 5.0	1.0	3	4.5
	6.0 to 7.0	5.0 to 6.0	1.0	3	5.5
	7.0 to 8.0	6.0 to 7.0	1.0	4	6.5



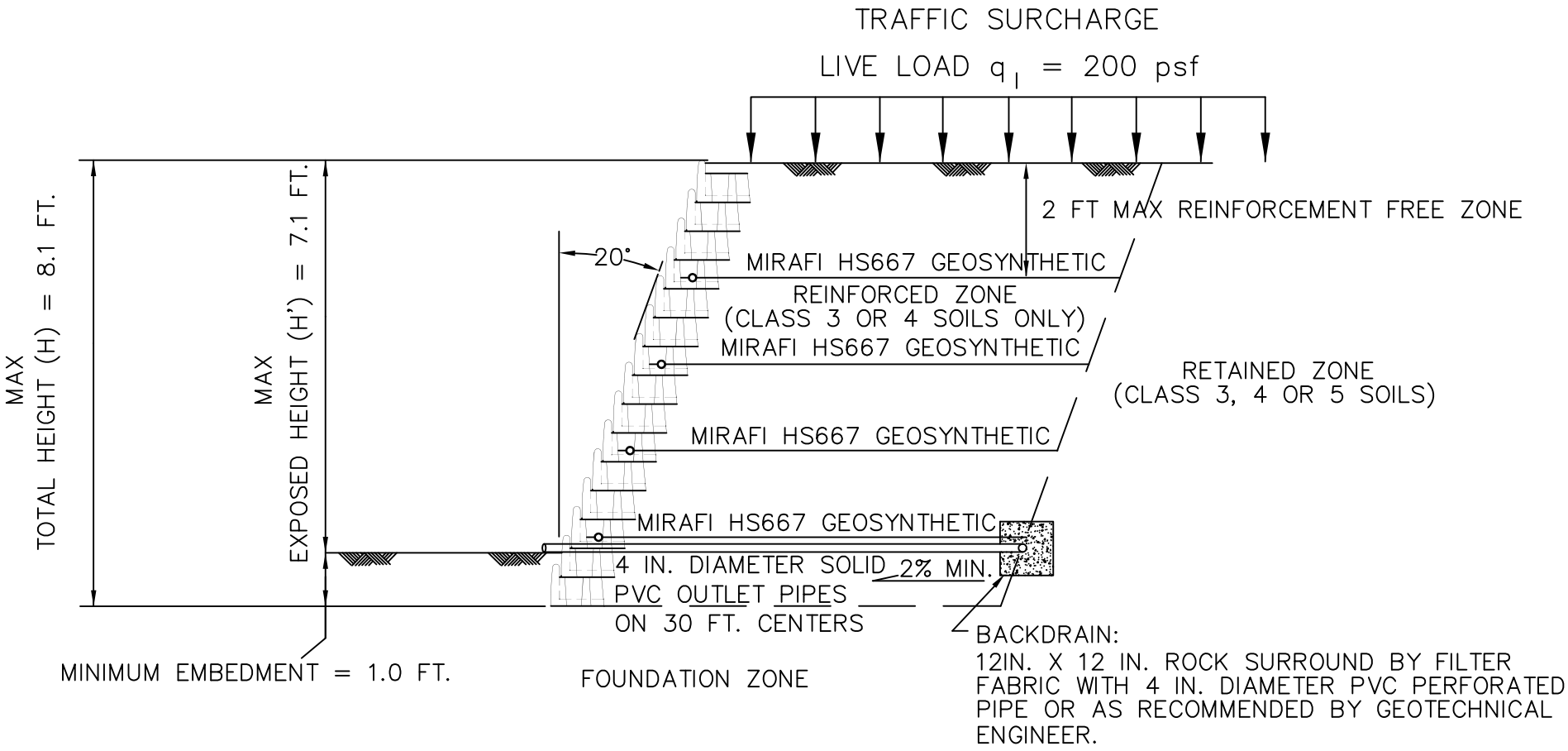
Typical Cross Section Through Maximum Height

NOT TO SCALE

CASE 1

CASE II
Level Backfill – Traffic Surcharge = 200 psf

CLASS OF SOIL per Table 1804.2 of the 2007 CBC	TOTAL WALL HEIGHT (H) (feet) INCLUDING EMBEDMENT	EXPOSED WALL HEIGHT (H') (feet)	EMBEDMENT DEPTH (H_{emb}) (feet)	NUMBER OF POSI-DURA® LAYERS	LENGTH OF POSI-DURA® REINFORCEMENT (feet)
3 GWand GP	4.3 to 5.0	3.3 to 4.0	1.0	2	3.5
	5.0 to 6.0	4.0 to 5.0	1.0	3	4.5
	6.0 to 7.0	5.0 to 6.0	1.0	3	4.5
	7.0 to 8.0	6.0 to 7.0	1.0	4	5.5
4 SW,SP, SM, SC, GM, and GC	4.3 to 5.0	3.3 to 4.0	1.0	2	3.5
	5.0 to 6.0	4.0 to 5.0	1.0	3	4.5
	6.0 to 7.0	5.0 to 6.0	1.0	3	5.5
	7.0 to 8.0	6.0 to 7.0	1.0	4	6.5
5 CL, ML, MH, and CH	4.3 to 5.0	3.3 to 4.0	1.0	2	3.5
	5.0 to 6.0	4.0 to 5.0	1.0	3	4.5
	6.0 to 7.0	5.0 to 6.0	1.0	3	5.5
	7.0 to 8.0	6.0 to 7.0	1.0	4	6.5



Typical Cross Section Through Maximum Height

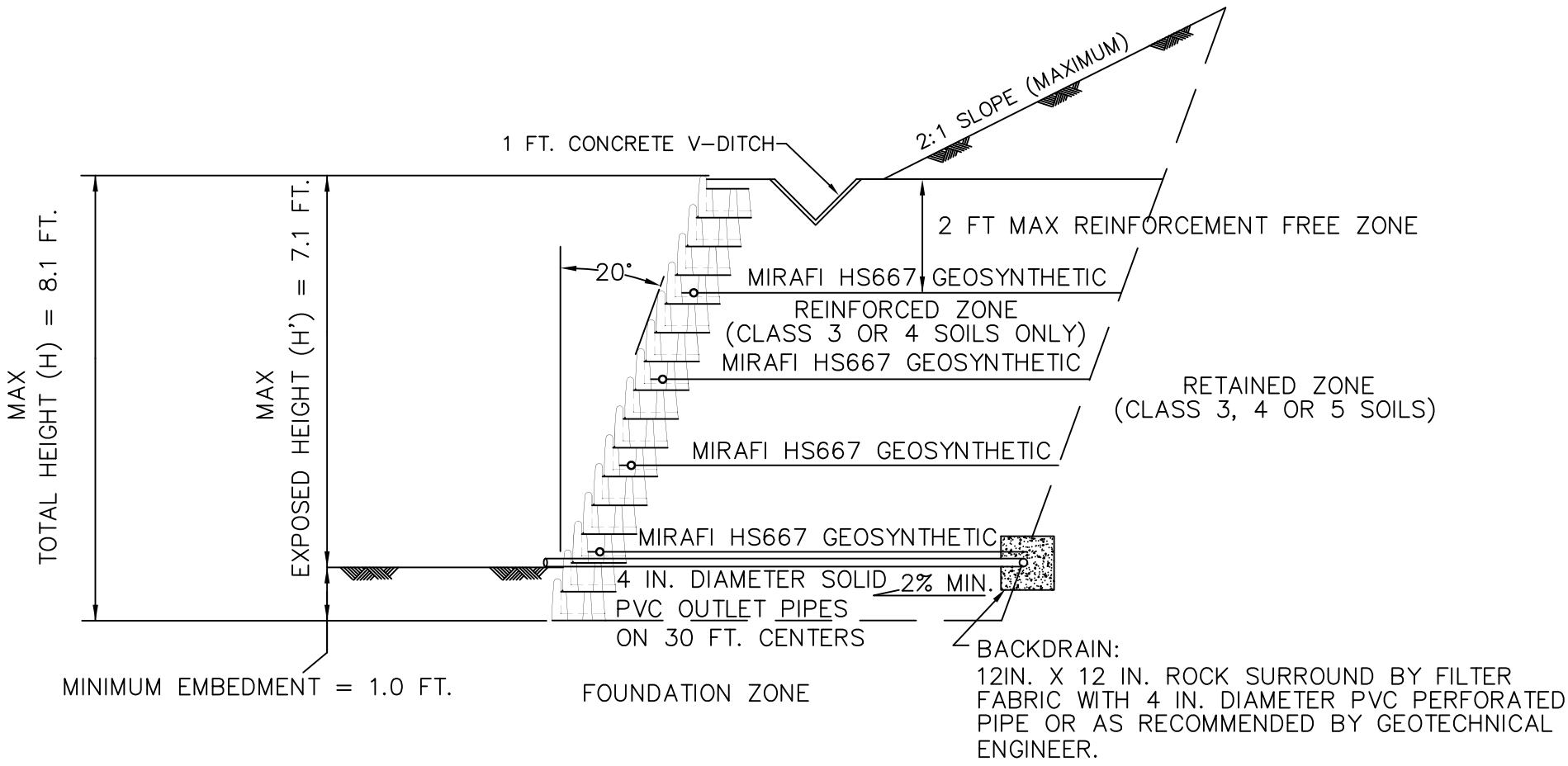
NOT TO SCALE

CASE 2

CASE III

2:1 Sloping Backfill

CLASS OF SOIL per Table 1804.2 of the 2007 CBC	TOTAL WALL HEIGHT (H) (feet) INCLUDING EMBEDMENT	EXPOSED WALL HEIGHT (H') (feet)	EMBEDMENT DEPTH (H_{emb}) (feet)	NUMBER OF POSI-DURA® LAYERS	LENGTH OF POSI-DURA® REINFORCEMENT (feet)
3 GW and GP	4.3 to 5.0	3.3 to 4.0	1.0	2	4.5
	5.0 to 6.0	4.0 to 5.0	1.0	3	5.5
	6.0 to 7.0	5.0 to 6.0	1.0	3	6.5
	7.0 to 8.0	6.0 to 7.0	1.0	4	7.5
4 SW,SP, SM, SC, GM, and GC	4.3 to 5.0	3.3 to 4.0	1.0	2	5.5
	5.0 to 6.0	4.0 to 5.0	1.0	3	6.5
	6.0 to 7.0	5.0 to 6.0	1.0	3	7.5
	7.0 to 8.0	6.0 to 7.0	1.0	4	8.5
5 CL, ML, MH, and CH	4.3 to 5.0	3.3 to 4.0	1.0	2	6.5
	5.0 to 6.0	4.0 to 5.0	1.0	3	7.5
	6.0 to 7.0	5.0 to 6.0	1.0	3	9.5
	7.0 to 8.0	6.0 to 7.0	1.0	4	10.5



Typical Cross Section Through Maximum Height

NOT TO SCALE

CASE 3

Limitations

The designs presented herein are based on the use of the specified products manufactured by Soil Retention Products, Inc. and general soil types identified by the 2007 California Building Code. It is the responsibility of the user of this design manual to verify the actual site soil conditions, and to construct the wall in accordance with this manual. A qualified geotechnical engineer may be retained to determine the soil type and any other geotechnical condition which may affect the design and stability of the wall and surrounding area, and to provide inspection services on a continuous basis during wall construction. The geotechnical engineer or his appointed representative shall observe and verify the installation of Verdura® blocks, geosynthetic reinforcement, and compaction of fill soil. All fill soil should be compacted to at least 90% of ASTM D 1557 maximum dry density.

The user of this design manual or his/her representatives agree, to the fullest extent permitted by law, to limit the liability of Soil Retention Products, Inc. and Soil Retention Designs, Inc. for any and all claims, losses, costs, damages of any nature whatsoever or claims expenses from any cause or causes, so that the total aggregate liability of Soil Retention Products, Inc. and Soil Retention Designs, Inc. shall not exceed $1,000.00 or the cost of wall materials, whichever is less. Such claims and causes include, but are not limited to negligence, professional errors or omissions, strict liability, breach of contract or warranty. The use of this design manual or his representatives also agree to fully protect, indemnify, hold harmless and defend Soil Retention Products, Inc. and Soil Retention Designs, Inc., their principles, officers, employees, and agents from and against any and all loss, cost, damage, injury, liability claims, liens, demands, taxes, penalties, interest or causes of action of every nature whatsoever resulting from the use of this design manual.

Excerpt from 2007 CBC Chapter 18

TABLE 1804.2
ALLOWABLE FOUNDATION AND LATERAL PRESSURE

CLASS OF MATERIALS	ALLOWABLE FOUNDATION PRESSURE (psf)[d]	LATERAL BEARING (psf/f below natural grade)[d]	LATERAL SLIDING	
			Coefficient of friction[a]	Resistance (psf)[b]
1. Crystalline bedrock	12,000	1,200	0.70	—
2. Sedimentary and foliated rock	4,000	400	0.35	—
3. Sandy gravel and/or gravel (GW and GP)	3,000	200	0.35	—
4. Sand, silty sand, clayey sand, silty gravel and clayey gravel (SW, SP, SM, SC, GM and GC)	2,000	150	0.25	—
5. Clay, sandy clay, silty clay, clayey silt, silt and sandy silt (CL, ML, MH and CH)	1,500[c]	100	—	130

For SI: 1 pound per square foot = 0.0479 kPa, 1 pound per square foot per foot = 0.157 kPa/m.

a. Coefficient to be multiplied by the dead load.

b. Lateral sliding resistance value to be multiplied by the contact area, as limited by Section 1804.3.

c. Where the building official determines that in-place soils with an allowable bearing capacity of less than 1,500 psf are likely to be present at the site, the allowable bearing capacity shall be determined by a soils investigation.

d. An increase of one-third is permitted when using the alternate load combinations in Section 1605.3.2 that include wind or earthquake loads.

Excerpt from Unified Soil Classification System

D 2487

TABLE 1 – SOIL CLASSIFICATION CHART

Criteria for Assigning Symbols and Group Names Using Laboratory Tests[A]					Soil Classification	
					Group Symbol	Group Name[B]
COARSE-GRAINED SOILS More than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve.	Clean Gravels Less than 5% fines[C]	Cu ≥ 4 and 1 ≤ Cc ≤ 3[E]		GW	Well-graded gravel[F]
			Cu < 4 and/or 1 > Cc >3[E]		GP	Poorly graded gravel[F]
		Gravels with Fines More than 12% fines[C]	Fines classify as ML or MH		GM	Silty gravel[F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	Cu ≥ 6 and 1 ≤ Cc ≤ 3[E]		SW	Well-graded sand[I]
			Cu < 6 and/or 1 > Cc > 3[E]		SP	Poorly graded sand[I]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH		SM	Silty sand[G,H,I]
			Fines classify as CL or CH		SC	Clayey sand[G,H,I]
FINE-GRAINED SOILS 50% or more passes the No. 200 sieve	Silts and Clays Liquid Limit less than 50	Inorganic	PI > 7 and plots on or above "A" line[J]		CL	Lean clay[K,L,M]
			PI < 4 or plots below "A" line[J]		ML	Silt[K,L,M]
		Organic	Liquid limit – oven dried	<0.75	OL	Organic clay[K,L,M,N]
			Liquid Limit – not dried			Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	Inorganic	PI plots on or above "A" line		CH	Fat clay[K,L,M]
			PI plots below "A" line		MH	Elastic silt[K,L,M]
		Organic	Liquid limit – oven dried	<0.75	OH	Organic clay[K,L,M,P]
			Liquid limit – not dried			Organic silt[K,L,M,Q]
HIGHLY ORGANIC SOILS		Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve.

[B] If the field sample contained cobbles or boulders, or both, add " with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols:
GW-GM well-graded gravel with silt
GW-GC well-graded gravel with clay
GP-GM poorly graded gravel with clay
GP-GC poorly graded gravel with clay

[D] Sands with 5 to 12% fines require dual symbols:
SW-SM well graded sand with silt
SW-SC well graded sand with clay
SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, ad "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel", whichever is pre-dominant.

[L] If soil contains ≥ 30% plus No. 200, pre-dominantly sand, add "sandy" to group name.

[M] If soil contains ≥ 30% plus No. 200 predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" Line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.