Shoreline, Waterway and Retention Pond Protection

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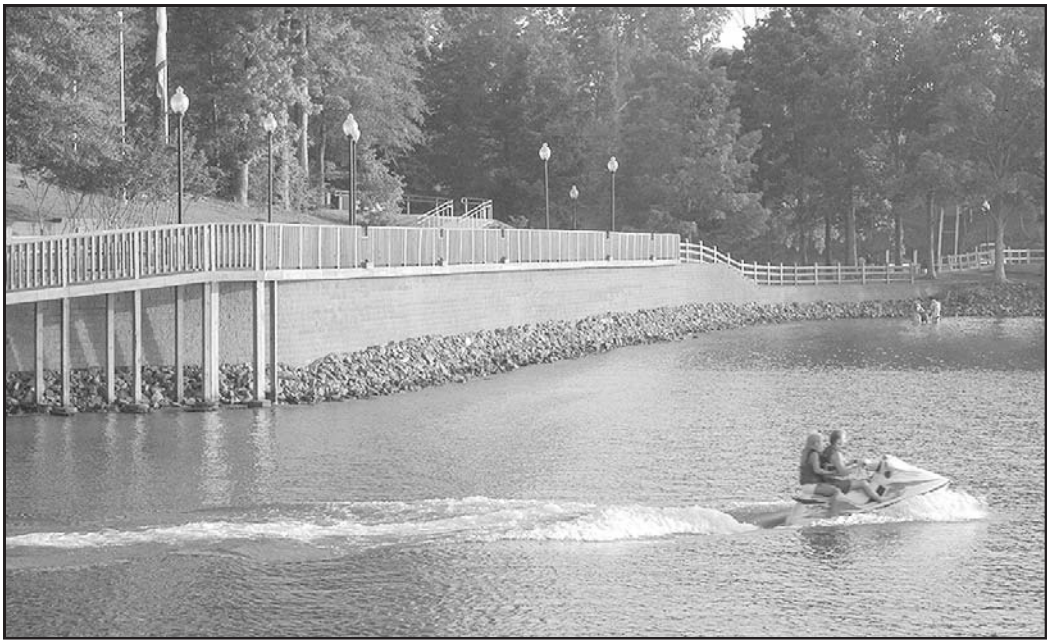
VERSA-LOK® Retaining Wall Systems have rapidly earned engineering approval for use on a growing number of diverse shoreline and waterway installations. This bulletin features basic design and installation guidelines for VERSA-LOK segmental retaining walls (SRWs) as used in retention ponds, lake and stream shorelines, channels, and other waterway applications. These guidelines are not intended for use on any particular installation, as site conditions and specific design parameters will vary.



ADVANTAGES OF VERSA-LOK SYSTEMS IN WATER APPLICATIONS

There are several advantages to using the VERSA-LOK system for water management, shoreline and stream bank erosion control, and open channel applications:

- The system is free draining. Because no mortar is used between units, the VERSA-LOK wall allows water to weep through joints in the wall. This helps to minimize buildup of hydrostatic pressure behind the wall.
- The unique VERSA-LOK dry-stack system is a relatively flexible structure that is founded on an aggregate leveling pad foundation. This allows minor movement and settlement of the system without visual distress. VERSA-LOK units move and adjust relative to each other without loss of function.
- VERSA-LOK systems utilize solid, durable, high-strength concrete SRW units. These characteristics make the system highly resistant to rapid water flow velocities, face spalling and destructive impact from floating debris.
- VERSA-LOK systems are generally easier and faster to construct than systems requiring formwork or poured, reinforced footings. SRW units can be installed manually without the need for heavy equipment.

TECHNICAL BULLETIN

This Technical Bulletin is the first in a series of informational papers that provide specific application ideas and installation tips for VERSA-LOK® Retaining Wall Systems. Additional information is available in our *Design & Installation Guidelines.*

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TECHNICAL AND INSTALLATION ISSUES

Whenever an SRW is permanently or periodically in water, certain concerns must be addressed during project development. These concerns include: foundation, hydrostatic pressure, internal drainage, rapid draw down, surface water control, scour, ice forces, and backfill materials. Designs will vary with type of water application (as seen in Figures 1-4). A project specific design should be prepared by a qualified Professional Engineer (P.E.).

FOUNDATION

A competent foundation is essential to the structural integrity of any SRW, especially those located in water environments. Often, suitable conditions for a foundation do not exist at a shoreline site. All loose or soft soils should be excavated and replaced with properly compacted backfill. Foundation soils must be stiff, firm, and have sufficient capacity to support wall weight.

Water is often encountered where the base will be constructed. Contractors can dewater the foundation area by sealing it off with sand bags or sheet piles and removing water with pumps.

Rather than dewatering, sometimes a reinforced aggregate base can be placed in the wet. This type of base may also improve the foundation over soft soils.

A reinforced base can consist of open-graded, free-draining gravel (no fines) reinforced with geogrid and wrapped in geotextile fabric (Figure 2). The geotextile reduces the movement of fine particles into the granular base. The contractor may opt to place a poured concrete footing in the wet, with the concrete displacing water during the pour. A concrete footing, however, must be placed below the seasonal frost depth.

For water applications, minimum wall embedment should be 1 ft, (two VERSA-LOK® Standard units). Additional embedment beyond this minimum will be needed depending on wall height, wave action, and current conditions.

HYDROSTATIC PRESSURE

Adequate drainage of water in the retained soils must be provided to avoid buildup of hydrostatic pressure behind the wall. Standard designs assume no hydrostatic pressure on the wall. Also, typical designs usually do not account for the reduction in soil strengths and soil interaction caused by saturation.

It is important to remove accumulated water behind the wall quickly. In most cases, a properly engineered drainage system can be designed to efficiently remove excess water behind the wall.

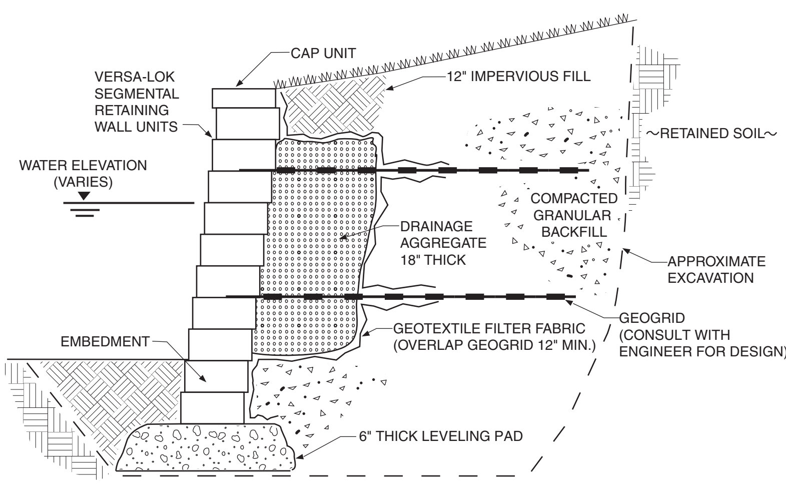


FIGURE 1 Retention Pond — Typical Section
(scale: none)

INTERNAL DRAINAGE

There are four possible components of a good internal drainage system that effectively reduce hydrostatic pressures in water applications.

Drainage aggregate

This material should be clean, open-graded 3/8" to 3/4" diameter, angular gravel, with no fines, to allow for the free flow of water through the system. A minimum of 18" of this aggregate should be placed immediately behind the wall face (Figure 1).

Drainage pipe

The drainage aggregate may need a perforated drainage pipe at the base to carry accumulated water away quickly. Drain pipes at intermediate levels may be needed for sustained high water levels. All drainage pipes should have adequate flow capacity and positive slope to direct water away by gravity (Figure 2).

Drainage blanket and chimney

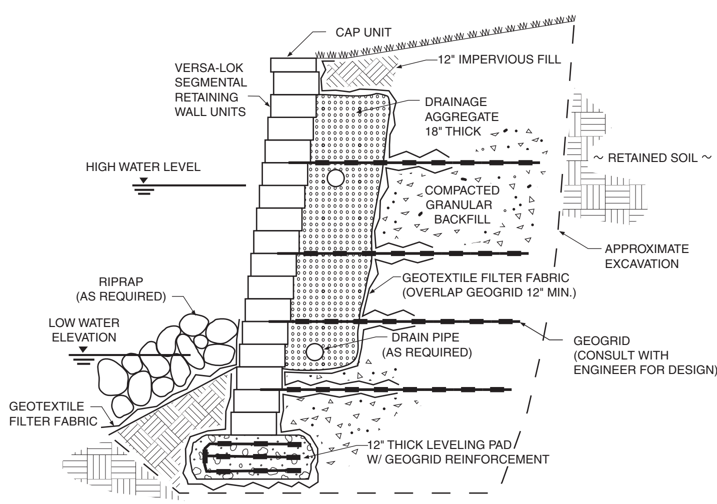
When groundwater rises seasonally into the compacted granular backfill and retained soil zones, a blanket drain may be necessary to remove water as it seeps into this soil mass (Figure 3A). The drainage aggregate layer is extended horizontally to form a blanket across the entire width of the reinforced wall and soil zone. A chimney drain can provide an additional drainage path to channel water from behind the wall (Figure 3B).

VERSA-LOK® Retaining Wall Systems have been used on many agency shoreline projects.

Geotextile filter fabric

In wall systems that have water moving through the backfill, fine soil particles can migrate into the internal drainage aggregate—eventually clogging. Geotextile filter fabrics allow water to pass through pores but restrict movement of fine soil particles. Selecting an appropriate geotextile (based on both the opening size in the fabric and the grain size of the fines in the surrounding soil) is important to prevent the fabric itself from clogging (Figure 1-4).

FIGURE 2 Shore Protection — Typical Section
(scale: none)



RAPID DRAW DOWN

Rapidly fluctuating water levels in front of a wall can cause large water loads on an SRW. As water in front of the wall recedes quickly, the soil behind the wall may not drain as rapidly, causing a temporary hydrostatic pressure on the wall. Rapid draw down may occur after flooding in a channel, or when a detention pond quickly drains after a storm event.

Rapid draw down pressures may be addressed in two ways. Depending on the severity, it may be possible to eliminate such pressures by improving the internal drainage with drainage blankets and chimney drains. If this is not sufficient or practical, the engineer may be able to design for the temporary water load by increasing the length and strength of the geogrid reinforcement.

SURFACE WATER CONTROL

Grading at the top of the wall should provide positive slopes away from the SRW. A 12-inch-thick layer of impervious fill should be placed at the top of the wall. In cases where a wall may be topped over with flood waters, special attention should be given to minimize erosion at the top and ends of the wall.

SCOUR

Scour (the erosive force of moving water) at the toe of an SRW is due to continuous wave action, or fast-moving, channel or river flow currents. If left unprotected, the foundation below an SRW may deteriorate from these erosive forces. Whenever possible, the SRW base should be embedded below scour depth.

In less-critical applications, riprap and a geotextile filter fabric can often alleviate scour forces. (Figure 2).

In highly turbulent water conditions, a qualified engineer will require specific knowledge about flow rates and other causes of scour—perhaps a complete hydraulic analysis—to adequately design an SRW system for these applications.

The design of the riprap is very site specific. Generally, riprap protection should extend until the slope in front of the wall levels out. Riprap must be properly graded to function well and carefully placed so that large angular pieces do not puncture or displace the geotextile filter fabric.

FIGURE 3A **Drainage System — Wall Face and Blanket**
(scale: none)

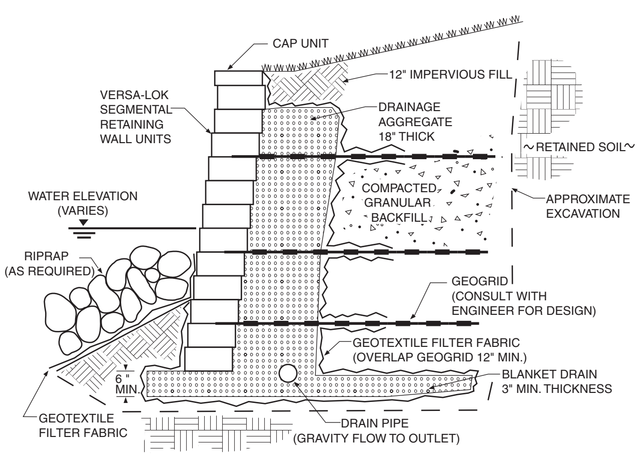
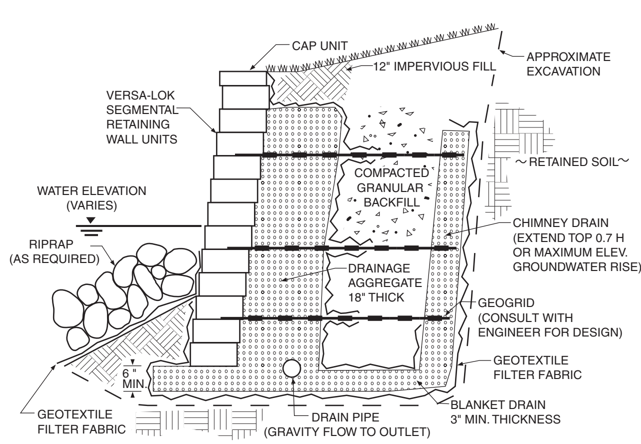


FIGURE 3B **Drainage System — Blanket & Chimney**
(scale: none)



ICE FORCES

In colder climates, ice forces can affect walls placed in water. Where ice forces are extreme, such as a seasonal occurrence of large, thick ice sheets, it may be impractical to design an SRW for these loads. Generally, there are three types of ice concerns that need to be considered: thermal expansion/contraction, uplift, and impacts. Temperature changes can create horizontal contraction or expansion loads when ice is confined. Changes in water level under ice sheets can exert uplift or downward forces. Possible impact forces of floating ice slabs in high velocity streams or heavy wave action should also be considered. Although solid VERSA-LOK® units provide superior durability, SRWs cannot be easily designed to resist large forces from the front of the wall. However, if a VERSA-LOK wall is pushed out of alignment by ice forces, the VERSA-LOK units can often be reused to rebuild the wall.

VERSA-LOK Systems increase retention pond capacity and maximize usage of surrounding land.

BACKFILL MATERIALS

For water applications, the preferred backfill material in the geogrid reinforced soil zone is well-graded, angular gravel (such as an aggregate road base material). This material provides relatively good drainage and maintains its properties well when saturated. Open-graded drainage gravel (no fines) is also used. However, this material can act as a "bathtub," collecting water quickly. This could overwhelm internal drainage systems and create hydrostatic pressures without proper design. Fine-grained soils, such as lean clays, may sometimes be used for reinforced backfill in less critical water applications, but the wall design must account for the effects of saturation on these finer soils.

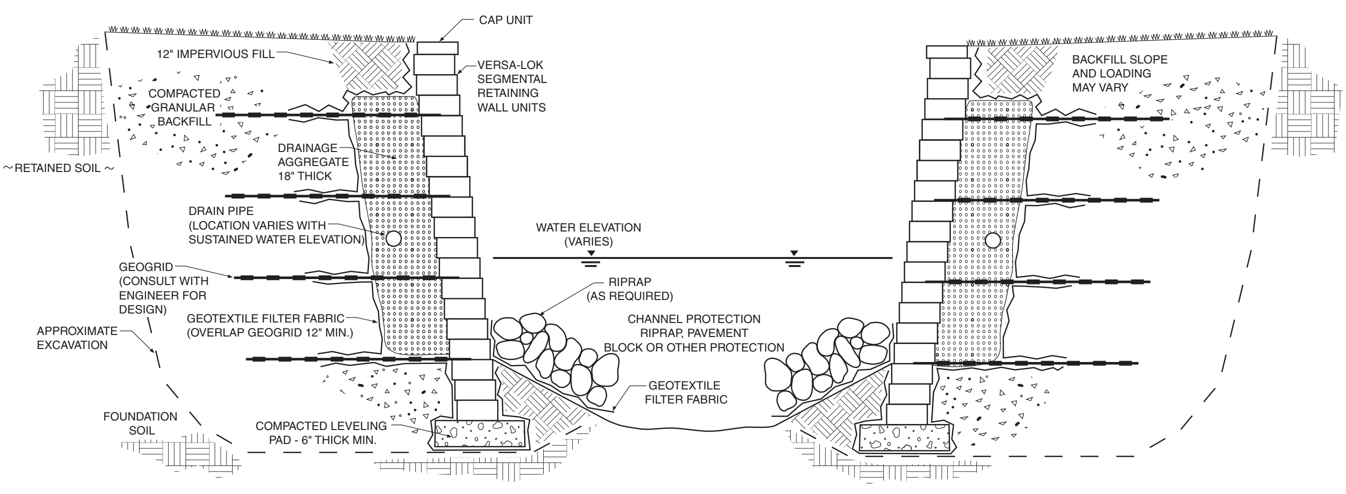


FIGURE 4 Channel Wall — Typical Section
(scale: none)

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Solid, durable, interlocking VERSA-LOK® units are ideally suited for channel and flood control projects.

VERSA-LOK walls can provide an attractive and stable border around lakes and ponds.

The material presented in this publication—including technical and engineering data, figures, designs, drawings, details, suggested procedures, and suggested specifications—is given as general information only. While every effort has been made to ensure its accuracy, this information should not be used or relied upon for any specific application without independent competent professional examination and verification of suitability and applicability. Anyone making use of the material does so at his own risk and assumes any and all liability from such use.

VERSA-LOK offers a variety of technical support including in-house engineering assistance, design details, and reference literature. Call 1-800-770-4525 or visit us at: www.versa-lok.com

This bulletin presents only basic guidelines for the design and installation of VERSA-LOK retaining walls in water applications. Additional information covering the subject of SRW design and installation, and hydraulic design criteria, both beyond the scope of this bulletin, is contained in the following reference documents:

Design Manual for Segmental Retaining Walls, Second Edition, National Concrete Masonry Association, 1996.

Highway Drainage Guidelines, Vol. VI, "Hydraulic Analysis and Design of Open Channels," American Association of State Highway and Transportation Officials, Inc., 1992.

Hydraulic Design of Flood Control Channels, U.S. Army Corps of Engineers, EM 1110-2-1601, 1 July 1991.

Design of Riprap Revetment, U.S. Federal Highway Administration Hydraulic Engineering Circular No. 11 (HEC-11), March 1989.

Hydraulic Design Criteria, U.S. Army Corps of Engineers loose-leaf data-book, available from the National Technical Information Service (NTIS), revised periodically.

Retaining and Flood Walls, U.S. Army Corps of Engineers Engineering manual EM 1110-2-2502.

Handbook of Hydraulics, Sixth Edition, Brater, E.F. and King, H.W., McGraw-Hill, 1976.

Stairs

2

VERSA-LOK® Standard units combined with VERSA-LOK Caps can create a variety of attractive and functional stairs that match the natural, classic look of VERSA-LOK Standard retaining walls. The size of VERSA-LOK Standard units—six inches high by 12 inches deep—easily adapts to construction of 2:1 (horizontal: vertical) step risers. Because VERSA-LOK Standard units are solid, they make stable step risers and can be easily modified for many types of stairs, including stairs inset into retaining walls or stairs that extend out from walls.

This technical bulletin provides a general overview of stair construction using VERSA-LOK Standard units and caps. However, none of the information presented here should be interpreted as final construction details. There are a variety of building codes that may apply to your project including step and railing requirements. The details shown here may not be in compliance with codes governing your project. Check with your local building code official and ensure any applicable stair details are met. Site conditions and design considerations will vary, so a qualified professional engineer should prepare a final, project-specific design based on actual site conditions.

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INSTALLING THE BASE PEDESTAL

For all types of VERSA-LOK® stairs, the "base pedestal" installation method is suggested for ease of construction. Using this method, the base courses beneath the step risers are all built at the same level. Then a pedestal of units is stacked to create subsequent step risers (Figure 1). While this method requires more units than simply cutting in a base for each riser, it can save substantial labor costs. This method also creates more accurate, level, and stable stairs.

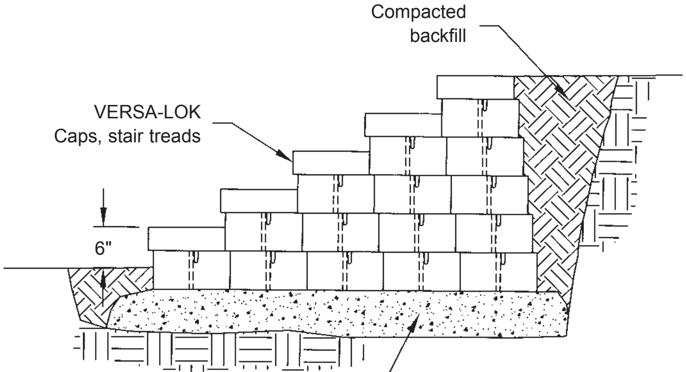


FIGURE 1

Careful preparation at the bottom of the pedestal is critical to the stability and levelness of the stairs. The leveling pad material should consist of crushed gravel, at least six inches thick. After placing and compacting the gravel, carefully check and adjust the level. A layer of fine sand may be used for final leveling. Place base course units on the leveling pad and check the level of the units front-to-back, side-to-side, and diagonally with a four-foot-long level. For more information regarding leveling pads and base installation, see Technical Bulletin No. 5—Base Installation.

The base course for stairs is usually buried 3-1/2 inches below the planned grade, leaving 2-1/2 inches of the unit exposed above grade. When a cap unit (about 3-1/2 inches high) is later placed on an embedded unit, it will create a six-inch-high step up from the grade (Figure 1).

Often, stairs are built into retaining walls, inset between sidewalls.

Create the remaining six-inch-high by 12-inch-deep risers by stacking courses of units in a pedestal. Shift each subsequent course of units forward about 3/4-inch, so they slightly overlap the row below (Figure 1). This will create an attractive overhang of the caps units when they are installed as treads.

If plans call for more than six risers, build the stairs in separate pedestals, each no more than five risers high (Figure 2). Building pedestals of more than five risers would bury more units than necessary.

Units placed in the stair pedestal are not pinned. The weight of the pedestal generally provides enough friction to keep stair units in place. If desired, use VERSA-LOK Concrete Adhesive to adhere each course to the one below. Be sure this completely cures before stairs are used, so the units do not shift (this can take several days).

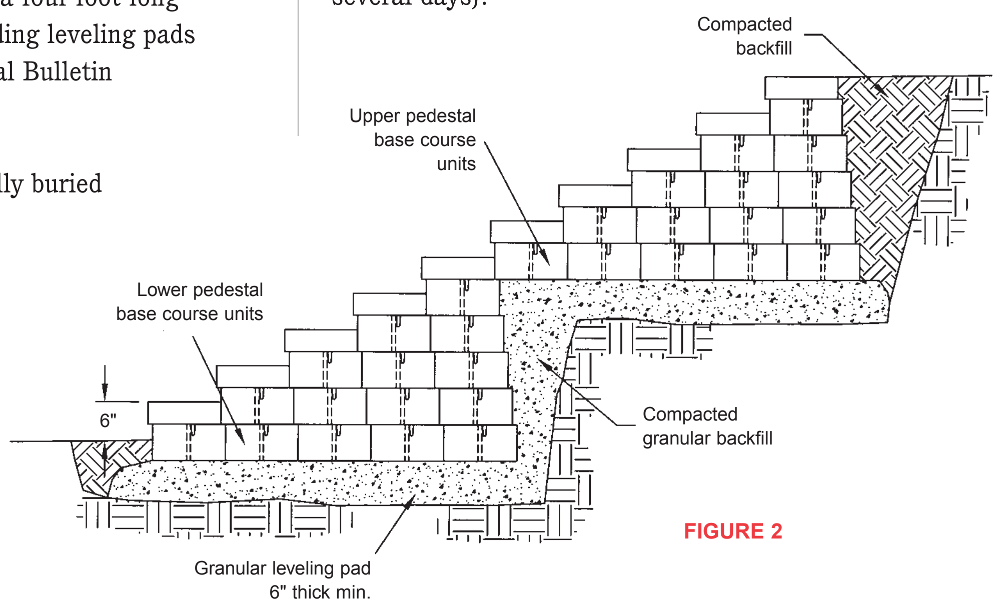


FIGURE 2

INSET STAIRS

Often, stairs are built into a retaining wall, inset between two sidewalls. These sidewalls usually turn back at 90-degree outside corners from the main retaining wall. The sidewalls are generally built vertical. This keeps the width of the risers the same throughout the height of the stairs.

To minimize cutting and special fitting, build the width of the stair risers equal to a whole number of units (each unit is 16 inches wide at the face). For example, risers could be 48 inches wide (three units), or 64 inches wide (four units) etc. Also, for each planned step, place a row of units in the base. For example, if the stairs are five risers high (2.5 feet), then place five rows of units in the base course (Figure 3).

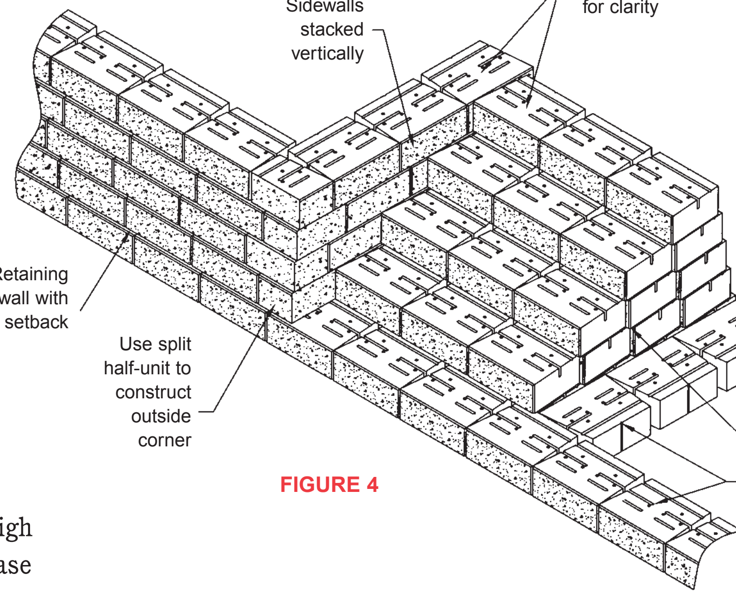


FIGURE 4

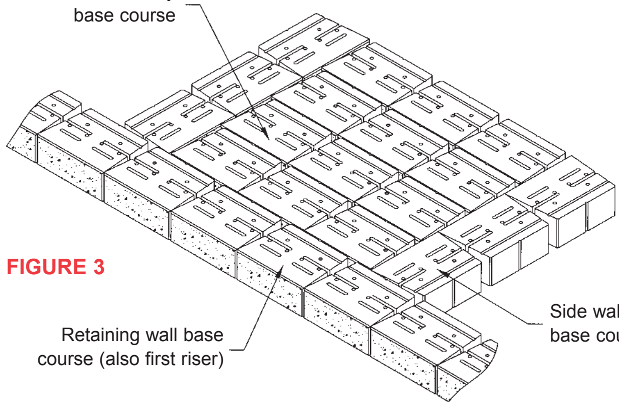


FIGURE 3

Level the base units for the retaining wall, the sidewalls and the stairs all at the same time.

The front of inset stairs is usually built in line with the main wall. The retaining wall base course then acts as the first riser for the stairs (Figure 3). Place subsequent risers according to the pedestal method and then place and adhere cap units as treads (see “Caps as Stair Treads” section).

Only after the entire stair pedestal is installed and capped should the vertical sidewalls be built. Start these walls by placing a half-unit at the outside corners of the stair assembly (Figure 4). The half-unit is simply a whole VERSA-LOK® Standard unit split down the middle, creating a textured face on the side that matches the front split face.

Working out from the half-unit at the corner, place whole units for the sidewalls and the front retaining wall. For each subsequent course, alternate the direction of the half-unit at the corner and build out from the corner. Remember, the sidewall units are usually stacked vertical, while the front retaining wall units are setback the standard 3/4-inch per course.

The sidewall units and the half-units at the corners cannot be pinned. Most of these units will be buried or kept in place by the stair pedestal. For the few units that are not restrained, adhere them with VERSA-LOK Concrete Adhesive.

When the sidewalls and front retaining walls are completed, cap these walls using the standard methods for capping VERSA-LOK Standard walls as described in Technical Bulletin No. 4—Caps.

With VERSA-LOK® units, the exposed sides of stair pedestals can have textured split faces.

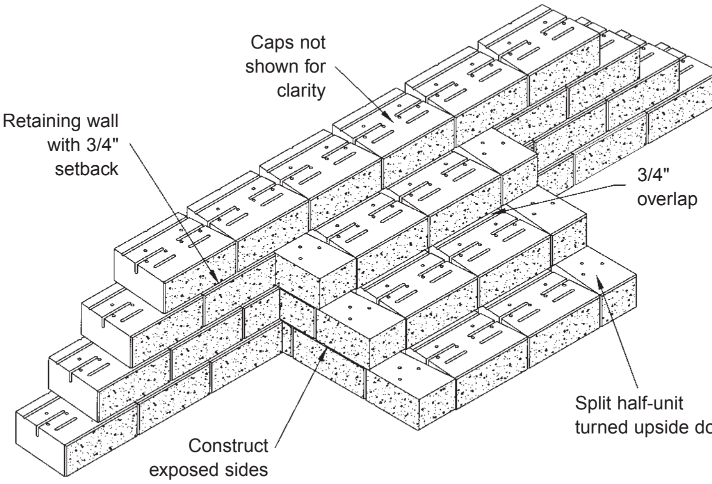


FIGURE 5

STAIRS EXPOSED ON BOTH SIDES

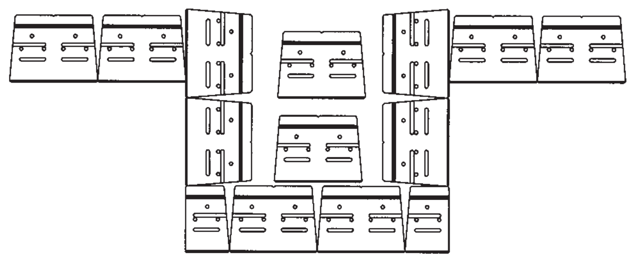
Rather than being inset, sometimes stairs extend out from a wall. In these cases, the sides of the stair pedestal will be visible. For aesthetics, these exposed sides can be built with textured split faces that match the front of VERSA-LOK Standard walls.

Place half-units at both edges of each riser. Similar to a 90-degree outside corner, the half-units provide a textured split face for the side of each riser. For the remaining portions of the sidewalls, place whole units with the front, textured face of the units facing out (Figure 5).

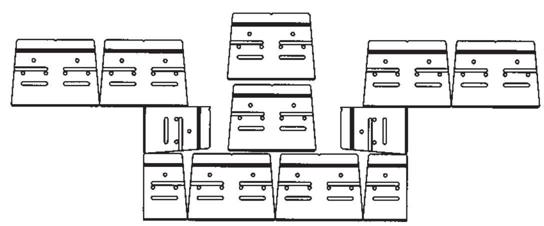
To minimize special fitting, build the exposed sidewalls vertical. This keeps the risers at the same width throughout the height of the stairs. If the exposed stairs extend out from a VERSA-LOK Standard wall, interlock each course of the sidewalls into the main retaining wall, similar to installing an inside 90-degree corner.

Level the base units of the stairs and the retaining wall at the same time. Figure 6 shows a suggested installation sequence for exposed stairs (four feet wide and two feet high) extending from a VERSA-LOK Standard retaining wall.

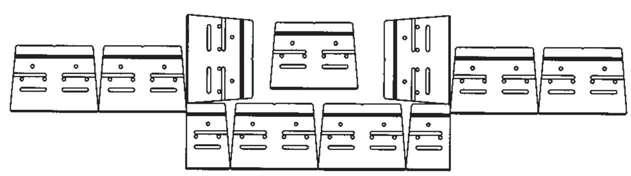
The units inside the pedestal are not visible and do not have to fit tightly. However, they should be arranged to provide proper support for the units above.



Base course



Second course



Third course

Top course

FIGURE 6

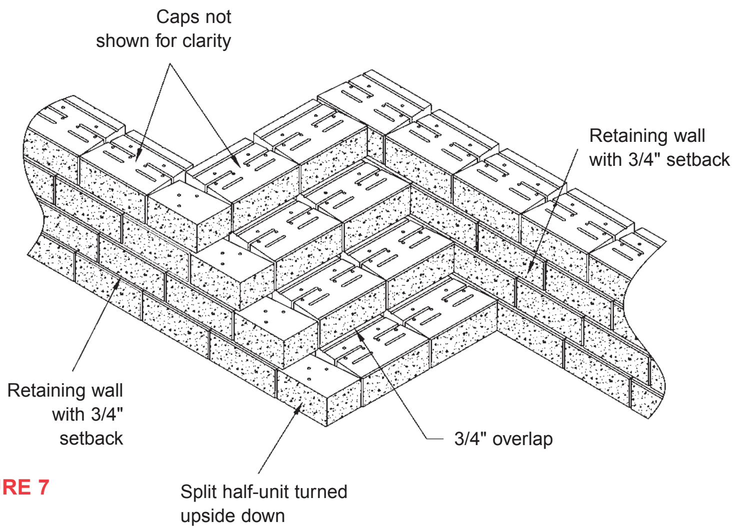


FIGURE 7

STAIRS EXPOSED ON ONE SIDE

Sometimes stairs are run along a retaining wall, with one side abutted into a wall and the other side exposed. For an attractive appearance, the exposed side of the stairs can be built with a split, textured face that matches the retaining wall (Figure 7).

Place a half-unit at the exposed side of each riser. This creates a 90-degree, textured corner. On the other side of the stairs, butt each riser into the retaining wall.

When the risers are abutted to a setback retaining wall, the exposed side of the risers will automatically also have a setback. If the exposed side of the stairs continues on to become a retaining wall, this setback in the risers will match the setback in the retaining wall it joins.

Level the base units for the stairs and the retaining wall at the same time. Figure 8 shows a suggested installation sequence for stairs with one side exposed (40 inches wide and two feet high).

The units inside the pedestal are not visible and do not have to fit tightly. However, they should be arranged to provide proper support for the units above.

GEOGRID REINFORCEMENT

If the sidewalls along inset stairs exceed four feet in height, geogrid soil reinforcement is required for sidewall stability. Generally, geogrid reinforcement is not needed within stair pedestals because the entire pedestal is made of a stable mass of units. However, for exposed stair pedestals with sidewalls exceeding four feet in height, geogrid may be required. See the *VERSA-LOK® Standard Design and Installation Guidelines* for information on geogrid installation. A qualified professional engineer should prepare a final, project-specific design based on actual site conditions.

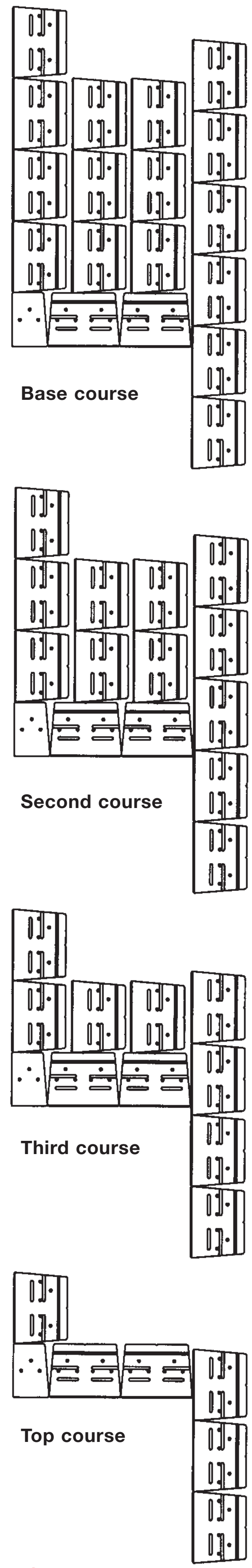


FIGURE 8

2

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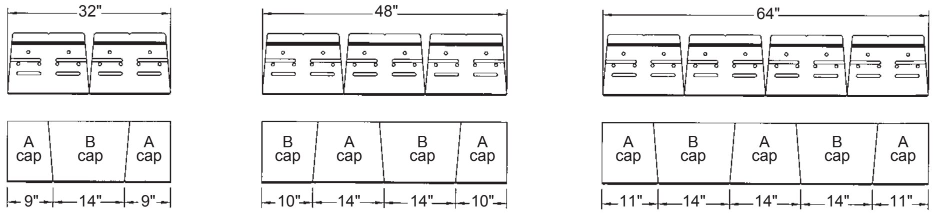

FIGURE 9

CAPS AS STAIR TREADS

VERSA-LOK® Cap units make excellent treads for stairs. Generally, start capping at the top step and work downwards. For straight steps, alternately place A and B caps along the length of the riser. The front of the caps should overhang the units below by about 3/4-inch.

When placing caps as treads for inset stairs, saw-cut or split the caps so they will fit in the space between the sidewalls. (Install caps on inset stairs before installing both sidewalls). Figure 9 shows example cap arrangements for straight, inset stairs in a variety of widths. For caps on steps that will be exposed on one or both sides, split the side of the caps at the exposed ends of the risers, similar to capping an outside 90-degree corner. For aesthetics, have the split side of the caps overhang the exposed side of the stairs by 3/4-inch.

Before adhering caps, complete any modifications and arrange them on the stairs to check alignment. Place two continuous, 1/4-inch beads of VERSA-LOK Concrete Adhesive on the step units. Set the caps into place and press them firmly into the adhesive. Adjust caps as needed before the adhesive sets. Allow at least 2-3 days (in warm weather) for adhesive to cure before using the stairs. For more information, see Technical Bulletin No. 4—Caps.

ICE REMOVAL

In northern climates, road salts are often used to de-ice stairs. Road salts and other de-icing chemicals can be detrimental to concrete products. Before using a particular de-icer on VERSA-LOK stairs, consult with your local VERSA-LOK supplier.

RAILINGS

Railings are needed for many stairs. Check with your local building codes regarding railing requirements. For more information on installing railings in VERSA-LOK walls and stairs, see Technical Bulletin No. 8—Fences, Railings, & Traffic Barriers.

Curves and Corners

3

VERSA-LOK® Standard units have a unique ability to provide a wide range of retaining wall curves and corners. Inside (concave), outside (convex) and serpentine curves are constructed with the same basic VERSA-LOK units by simply changing the alignment of units in the wall.

The same Standard unit is used to build inside 90° corners. And, by sawing or splitting the solid unit, you can build structurally stable interlocked corners ranging from 25° (outside) to 140° (inside). This flexibility and adaptability is unmatched by any other modular retaining wall system.

CURVES

Concave, convex and serpentine VERSA-LOK walls are made simply by fanning or bringing the tails of the units together. The trapezoidal shape of Standard units allows for construction of various radiuses while maintaining structural stability and tight vertical joints at the face of the wall. If a wall contains both curves and corners, start at the corners and work into the curves. Complete the entire first (base) course before proceeding to the second.

The radius of a curve will change as wall height increases, due to the 3/4-inch setback in each course. This changing radius will shift how units line up with the units below. The unique VERSA-LOK hole-to-slot pinning system easily accommodates this variation in curves. VERSA-LOK units do not need to overlap exactly halfway over units below (half-bond). However, units should overlap the units below by at least four inches. Because bond can vary in VERSA-LOK walls, vertical joints at the face can, and always should be, tight fitting (no gapping).

TECHNICAL BULLETIN

This Technical Bulletin is the third in a series of informational papers that provide specific application ideas and installation tips for VERSA-LOK® Retaining Wall Systems. Additional information is available in our *Design & Installation Guidelines.*

VERSA-LOK®
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CONVEX (OUTSIDE) CURVES

For convex curves, decrease space between backs of units, always keeping front joints tightly aligned. The minimum outside radius is 8' 0" without cutting any of the units (Figure 1). However, establishing a minimum radius for the top course of a few inches greater (8' 2" to 8' 4") is recommended to allow for creep, or in the event additional courses are added in the future. Because the units set back 3/4" per course, the radius of the curves becomes tighter as the wall increases in height; therefore, you need to "backward plan" the radius of the base course. The example below shows how to calculate the base course radius when the radius for the top course is known.

EXAMPLE

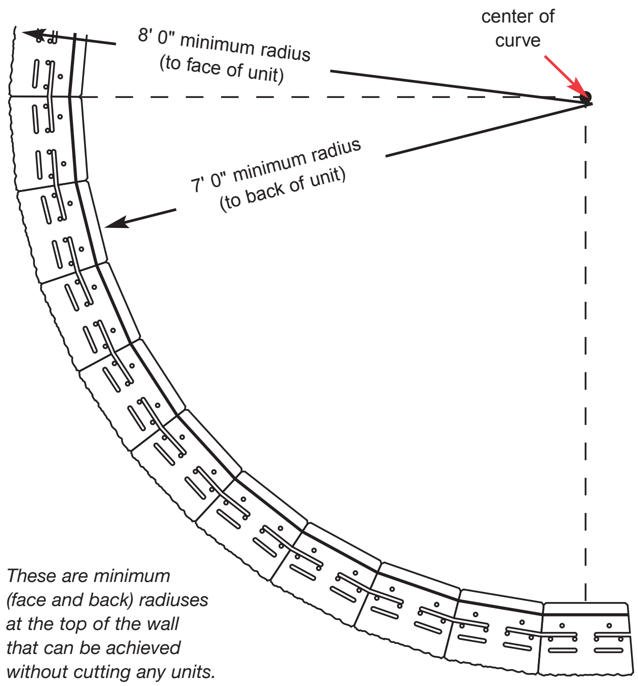
This example would be used only if you were building a four-foot-high convex curved wall and your desired radius at the face of the top course was 8' 2". The base course radius in this example would be 8' 7-1/4".

4-ft. wall = 8 courses (7 setbacks)
1 setback = 3/4"; 7 setbacks = 5-1/4"
Desired radius of finished wall: 8' 2"
8' 2" + 5-1/4" = 8' 7-1/4". This is your starting (base course) outside radius.

OUTSIDE CURVE TABLE

Wall height (in feet)	Number of courses	Bottom course outside radius	Minimum outside radius for top course
4 ft.	**8**	**8' 7-1/4"**	**8' 2"**
3.5 ft.	**7**	**8' 6-1/2"**	**8' 2"**
3 ft.	**6**	**8' 5-3/4"**	**8' 2"**
2.5 ft.	**5**	**8' 5"**	**8' 2"**
2 ft.	**4**	**8' 4-1/4"**	**8' 2"**
1.5 ft.	**3**	**8' 3-1/2"**	**8' 2"**
1 ft.	**2**	**8' 2-3/4"**	**8' 2"**
.5 ft.	**1**	**8' 2"**	**8' 2"**

FIGURE 1 Top Course Convex (Outside) Curve Plan



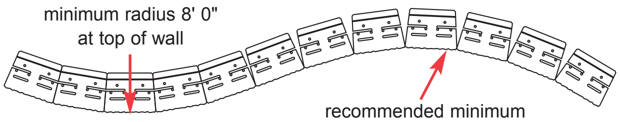
These are minimum (face and back) radiuses at the top of the wall that can be achieved without cutting any units.

Careful base course planning for convex curves is important when building tight curves.

CONCAVE (INSIDE) CURVES

Concave curves are constructed by merely fanning (opening up) the spacing between the backs of adjacent units. The minimum recommended radius, as measured to the face of the wall, for an inside curve is 6' 0" at the bottom of a wall (Figure 2). Tighter curves can be built and pinned, but the appearance of the wall becomes ragged; structurally there is no problem.

FIGURE 2 Serpentine Wall Detail



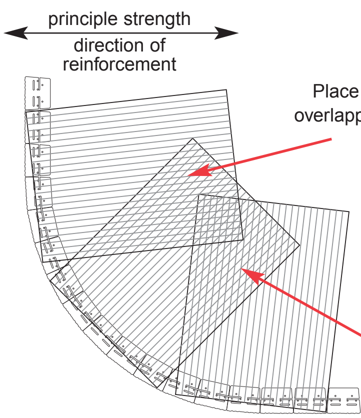
HOW TO LAY OUT A CURVE

1. Stake the center of the curve.
2. Swing layout line from center, marking the radius for bottom (base) course. See curve table.
3. Excavate and prepare base for the wall.
4. Place first unit on the radius desired.
5. Place adjacent units, check radius as you proceed.

CONVEX CURVE REINFORCEMENT

When placing geogrid behind convex curves, see Figure 3 for general reinforcement placement guidelines. For specific instructions, refer to geosynthetic manufacturer's guidelines.

FIGURE 3 Convex Curve

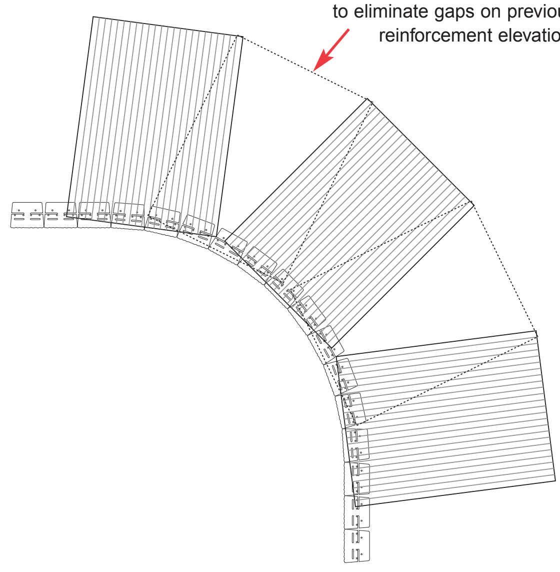


Build inside and outside curves with just one Standard VERSA-LOK unit — no specialty units needed.

CONCAVE CURVE REINFORCEMENT

When placing geogrid behind inside curves, simply diverge reinforcement from the face as shown in Figure 4. Place additional reinforcement on the course of units directly above the specified elevation (see dotted lines) so that it completely covers the gap. Keep successive layers of reinforcement from touching. Cover all gaps with reinforcement before backfilling.

FIGURE 4 Concave Curve



CORNERS

The solid, VERSA-LOK® Standard unit provides simplicity and flexibility for the construction of structurally stable corners. Not only does the VERSA-LOK system allow for easy construction of 90° inside and outside corners, but also for custom built corners at various angles.

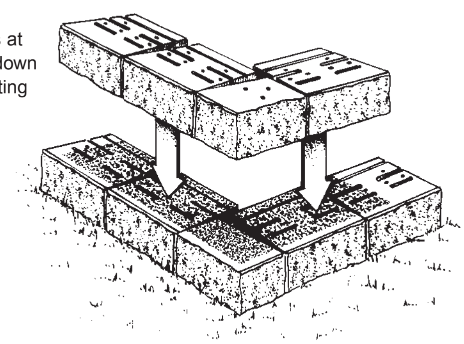
When building walls with corners, always start at the corners and work out from there. Do not adjust length or gap at the corner. Instead, make adjustments away from the corner. Install partial units in the middle of the wall where they are less visible. Create these partial units by saw-cutting whole units into pieces at least four inches wide.

OUTSIDE 90° CORNERS

Start outside 90° corners by splitting a Standard unit in half and alternating half units at the corners as shown in Figure 5. Do not miter corners. Turn half units upside down at corners to conceal splitting groove. Adhere these half units to the wall using VERSA-LOK® Concrete Adhesive, as they will not pin. This corner detail creates about a four-inch overlap of the units below. As each additional course is setback 3/4-inch, this overlap will vary. The unique VERSA-LOK hole-to-slot pinning system allows vertical joints to wander. Units do NOT need to overlap exactly halfway over units below (half-bond). However, units should overlap units below by at least four inches.

FIGURE 5 Outside 90° Corner

Place half-units at corner upside down to conceal splitting groove.



INSIDE 90° CORNERS

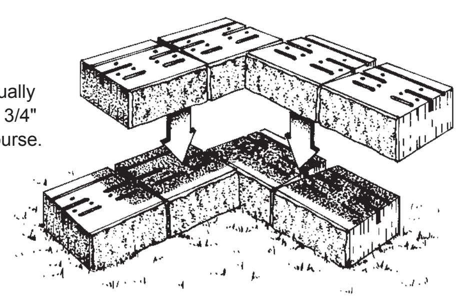
Half units are not required to start an inside corner; merely alternate the placement of a full-size VERSA-LOK unit past the inside corner (approximately 12" on the base course) as shown in Figure 6.

Curves, corners and a wide variety of steps are all possible with VERSA-LOK Standard units.

The alignment system of VERSA-LOK provides unmatched construction versatility.

FIGURE 6 Inside 90° Corner

Bond will gradually change due to 3/4" setback per course.



REINFORCEMENT PLACEMENT FOR CORNERS

For 90° outside corners, alternate the principle reinforcement direction whenever sections overlap (Figure 7). For 90° inside corners, extend geogrid past corners (Figure 8). Check your geosynthetic manufacturers' guidelines.

FIGURE 7 Outside Corner

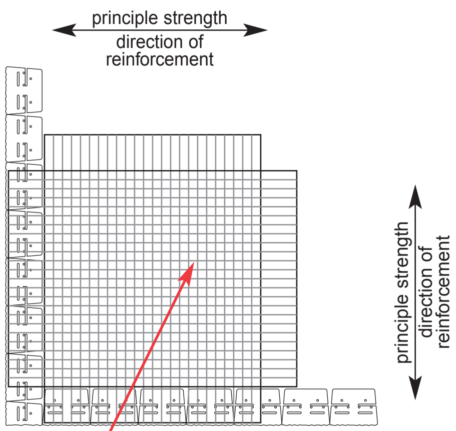
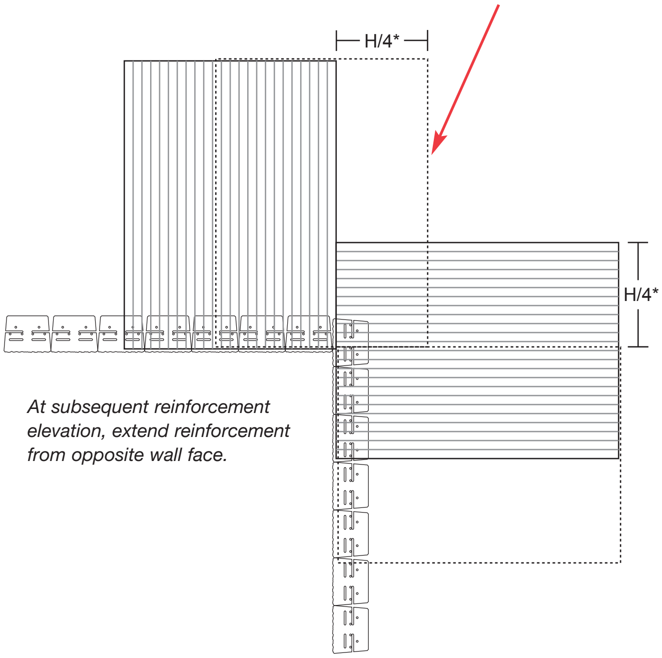


FIGURE 8 Inside Corner



*Extend reinforcement beyond wall face at a distance equal to 1/4 of the height of the wall (H).

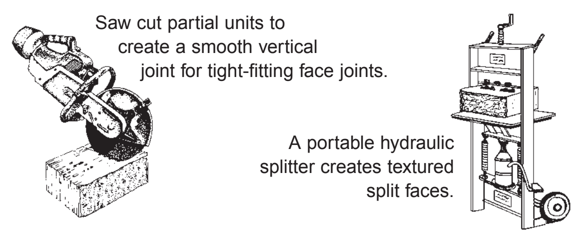
Example: H = 12' wall, extension = H/4 = 3'

SPECIALTY CORNERS

A variety of custom inside and outside corners (other than 90°) can be made with VERSA-LOK® Standard units. Use the illustrations provided in Figures 9 through 13A as guidelines when designing and building specialty corners.

The sets of illustrations for each corner arrangement represent alternate courses. Split the units where textured faces are desired and visible; saw cut the units when straight edges are needed to fit tightly next to adjacent units.

Alternating outside corner units should always overlap; do not butt or miter corners. If corners are butted or mitered, walls could separate at the corner due to ground movement.



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ADDITIONAL CUSTOM CORNERS

FIGURE 10 Low Angle Outside Corner

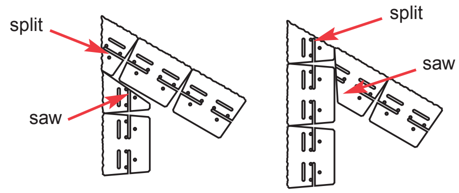


FIGURE 11 Near Right Angle Outside Corner

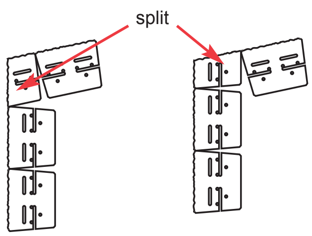


FIGURE 12 Low Angle Inside Corner

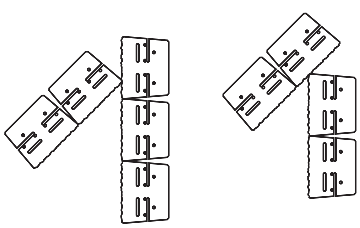


FIGURE 13 Large Angle Inside Corner

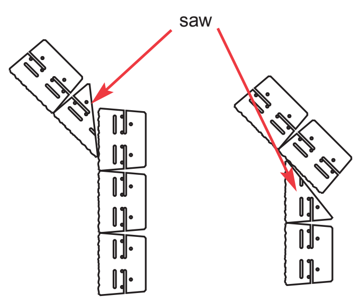
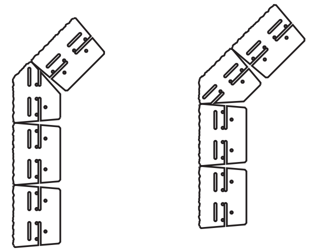
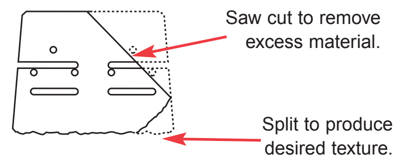


FIGURE 9 Large Angle Outside Corner





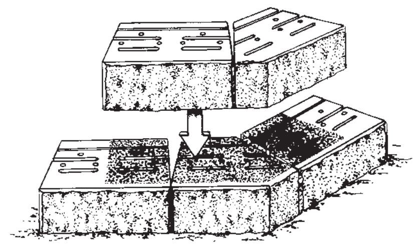
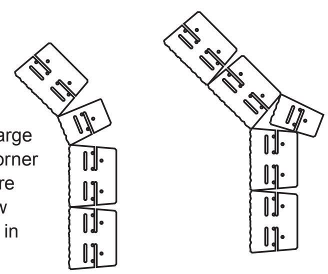
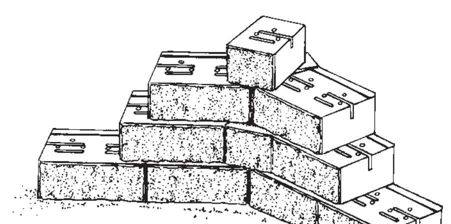


FIGURE 13A Large Angle Inside Corner *(Optional)*

This optional large angle inside corner does not require the special saw cuts illustrated in Figure 13.





Place full and half standard units at the desired angle.

TECHNICAL BULLETIN

For more detailed information regarding design and installation, please contact your local dealer or VERSA-LOK® Retaining Wall Systems.

Made worldwide under license from VERSA-LOK Retaining Wall Systems. U.S. Patent D319,885, U.S. Patent D321,060, U.S. Patent D341,215, U.S. Patent D346,667, U.S. Patent D378,702, U.S. Patent D391,376, U.S. Patent D430,680, U.S. Patent D435,302, U.S. Patent D439,678, U.S. Patent D452,332, U.S. Patent D458,387, U.S. Patent 6,488,448 and other U.S. patents pending;

Canadian Industrial Design Registration No. 63929, No. 71472, No. 73910, No. 73911, No. 73912, No. 77816, No. 79058, No. 82288, and No. 89084.

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Caps

VERSA-LOK® Caps provide an easy-to-install, attractive finishing touch to the top of VERSA-LOK® Retaining Walls. Like VERSA-LOK wall units, VERSA-LOK Cap units are solid. The cap units also have textured split-faces and colors that match retaining wall units.

VERSA-LOK Caps come in two types, A- and B-Caps (Figure 1). Both cap types have the same area at the front but taper to different widths at the rear. These two cap units allow capping of many wall alignments including straight walls, inside and outside curves, and stairs. The caps are secured with high-strength, flexible, VERSA-LOK Concrete Adhesive.

The front of VERSA-LOK Caps may be placed flush, setback, or overhanging the faces of the VERSA-LOK units below. The preferred method is to overhang cap units about 3/4-inch, creating an "eyebrow" on top of the wall (Figure 2). This creates an attractive accent shadow on the wall. Also, overhanging cap units allows for slight adjustments to hide any minor misalignment in the wall below.

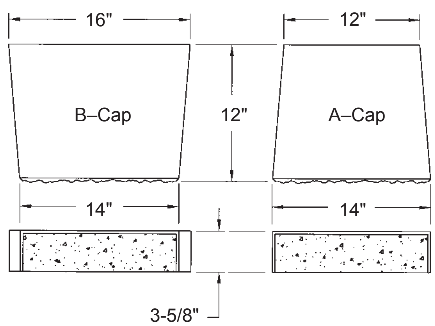

FIGURE 1

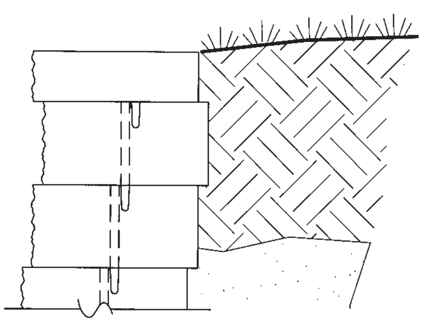

FIGURE 2

4

TECHNICAL BULLETIN

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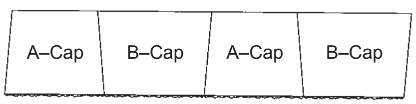
VERSA-LOK® Cap units help create an "eyebrow" effect on the top of walls.

CAPPING STRAIGHT WALLS

For straight walls, alternately place A and B caps along the length of the wall (Figure 3). Use a string line along the back of the cap units to keep them aligned and straight. Start at fixed ends of the wall and work away from them. Saw-cut partial units as needed to fill any remaining gaps between the A and B caps (See Saw-Cutting Cap Units section).

FIGURE 3



CAPPING CURVED WALLS

For tight convex (outside) curves, use A caps (Figure 4). For tight concave (inside) curves, use B caps (Figure 5). For more gradual curves or serpentine curves, a combination of A and B caps may best fit the curves.

FIGURE 4

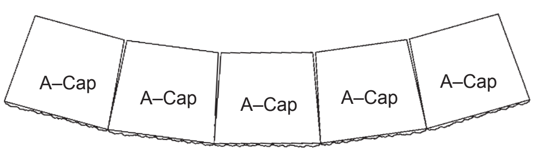
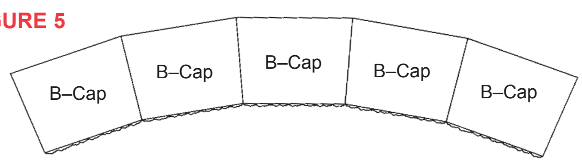


FIGURE 5



On all but the tightest curves, some gapping at the back of the caps will be needed to match wall alignment. Do not adjust caps by gapping at the front; the front joints between caps should be kept tight. Generally, gaps of up to 1/2-inch at the back of the cap units are considered acceptable. To completely eliminate gapping on most curves, saw-cutting the sides of cap units may be necessary. (See Saw-Cutting Caps Units section).

ADHERING CAPS

VERSA-LOK® Concrete Adhesive is suggested for adhering caps because it is a premium, high-molecular-weight polymer, designed for superior performance in retaining wall applications. It has exceptional adhesion, elasticity, and resistance to shear stress not provided by ordinary concrete adhesives.

Do not use rigid adhesives or mortar to secure caps. VERSA-LOK walls may move slightly (especially in areas subject to freeze/thaw cycles) causing the rigid adhesive bond to fail.

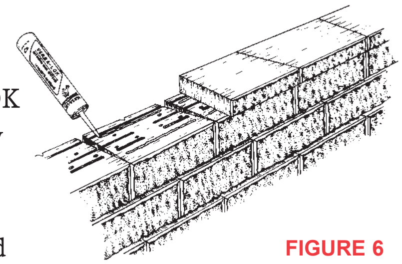


FIGURE 6

Before adhering caps, pre-arrange a group of four to five caps, starting at one end of the wall. Check the alignment of these caps and modify any as needed. After ensuring proper cap arrangement, remove this first group of cap units. Clear off any debris or dust.

Place two continuous, 1/4-inch beads of VERSA-LOK Concrete Adhesive on the wall units to be capped (Figure 6). Set the prepared group of cap units in place and press them firmly into the adhesive. Adjust caps as needed. Continue capping the remaining length of the wall in groups of four to five cap units at a time, fitting and adhering the groups as you go. Do not apply adhesive if wall units are too wet for the adhesive to stick.

Allow at least 2-3 days (in warm weather) for adhesive to cure. Thanks to the unique secondary-cure mechanism of VERSA-LOK Concrete Adhesive, its adhesion properties improve with time and weathering. In cold weather, keep the tubes of adhesive warm before applying.

SAW-CUTTING CAP UNITS

For most walls, some cap units must be saw-cut. Often, saw-cutting partial units is needed to adjust lengths of the wall cap between fixed points (wall ends or corners). Saw-cutting creates a smooth edge on the side of a cap unit, so it will fit tightly against other cap units or any adjacent structures.

Saw-cutting can easily be done in the field. Start by laying caps at each fixed point. Then work away from these points until the cap units nearly meet, leaving only a gap smaller than a whole cap unit. Saw-cut a partial cap unit to fit in this remaining gap. Try to keep the remaining gap towards the center of the wall. This helps hide smaller cap pieces.

For aesthetics, keep partial cap units at least four-inches wide. If any remaining gaps are smaller than this, make them bigger by cutting down the width of a cap unit placed next to the gap. Then saw-cut a wider partial cap unit to fill this bigger gap.

SPLITTING CAP UNITS

Splitting cap units is most often needed when the side of caps will be exposed, such as outside corners or where the top of the wall steps down. Splitting creates a textured face on a visible side of a cap unit, so it will match the textured front faces of caps and wall units.

To split a cap, score the top and bottom of the cap with a chisel at the location and angle of the needed split. At the scored line, split the cap unit with a hammer and chisel. A minimum split thickness of two-inches is needed for an accurate split. Alternately, a mechanical splitter can be used.

CAPPING CORNERS

When capping walls with corners, start by modifying and laying the cap units for the corner first. If there are several corners, remember to start laying caps at each of the corners and work out from them, meeting the caps about halfway between the corners. This keeps the smaller partial cap units hidden from the corners. For an outside corner, split the cap unit to match the corner angle in the wall below. For inside and outside corners, saw-cutting the side of the adjacent cap unit is necessary to create a tight fit against the corner cap unit. Figure 7 illustrates suggested cap modifications and arrangements for a variety of corners.

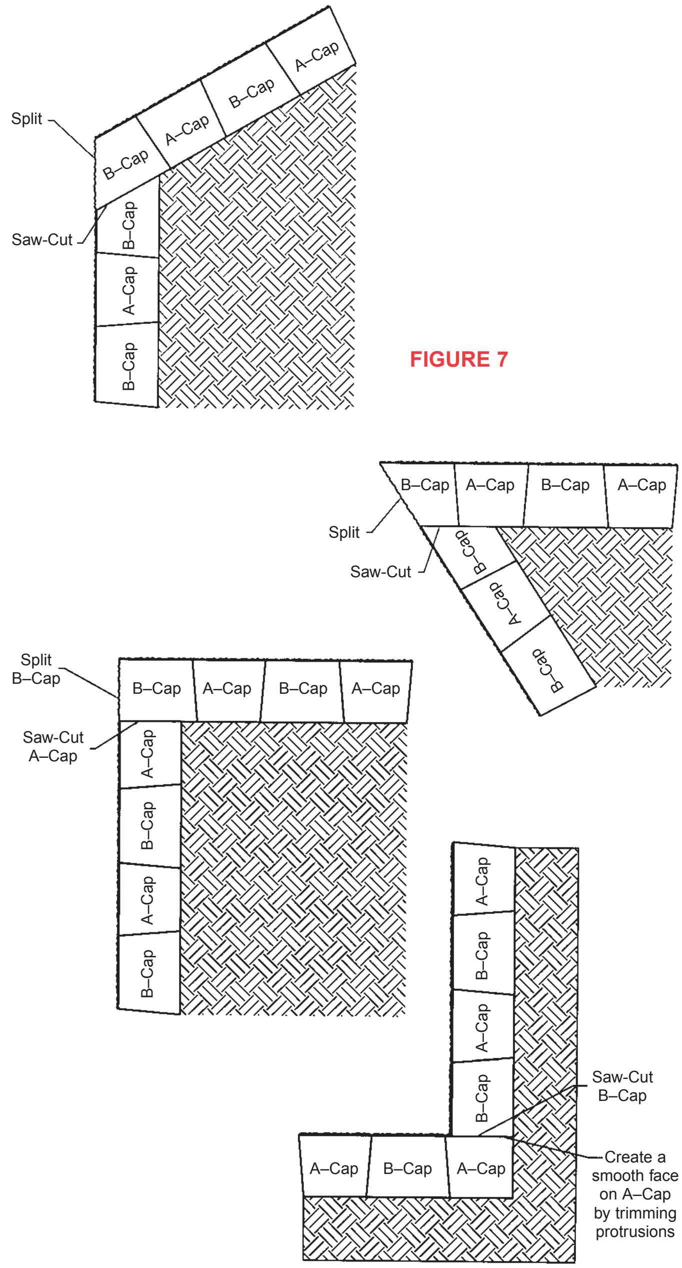


FIGURE 7

CAPPING STAIRS

VERSA-LOK Cap units make excellent treads for stairs, too. When capping stairs inset between two walls, saw-cut or split the caps to fit between the side-walls (Figure 8). For ease of installation, place and adhere the caps before building the side-walls. When placing caps on stairs extending out from walls (exposed on one or both sides), split the side of the caps at exposed end(s) of each riser, similar to capping an outside 90-degree corner.

When adhering caps as stair treads, remember VERSA-LOK Concrete Adhesive can take several days to cure.

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TECHNICAL BULLETIN

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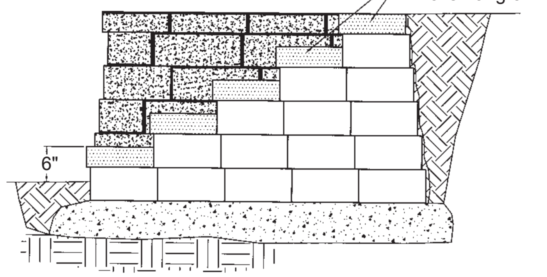
Do not allow stairs to be used until caps are secure. See Technical Bulletin No. 2 for more information on installation of VERSA-LOK stairs.

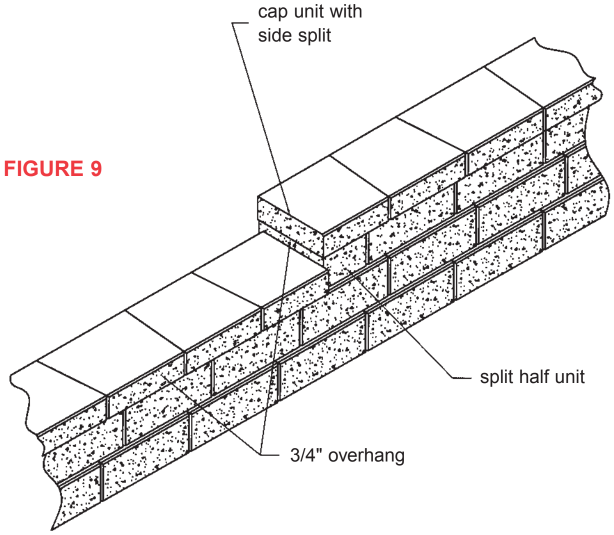
FIGURE 8



CAPPING TOP-OF-WALL STEP-DOWNS

Often the tops of walls are stepped down to match changing grades behind the wall. Where a course of units ends and steps down, split the exposed side of the cap unit to create an attractive textured end to each course. The split side of the cap should overhang the split half-unit below by 3/4-inch, similar to the suggested cap overhang at the front (Figure 9).

FIGURE 9



ESTIMATING CAPS

The first step in estimating caps is determining the length of planned wall. For curved walls, be sure to figure the whole length of the wall along the curves, not just the straight-line length. Determine the number of cap units needed by multiplying the lineal feet of wall by 0.86. Round this number up to nearest whole number of caps. Order extra caps to cover losses due to saw-cutting and splitting, especially for walls requiring corners or other specialty fitting.
For straight walls, half the caps will be type A and half type B. For tightly curved walls, all caps will be type A for outside curves and type B for inside curves. For gradual curves, a mix of A and B caps may be needed.

CAP OPTIONS

VERSA-LOK Cap units provide an easy-to-install, flexible capping system with an appealing look that matches VERSA-LOK retaining wall units.
However, other products such as concrete pavers, natural stone, or precast concrete may be appropriate capping alternatives, with proper design. Be sure any alternate capping system has sufficient flexibility or jointing to accommodate some movement in retaining wall units, especially in northern climates subject to freeze/thaw cycles. Also ensure capping systems can be properly adhered to retaining wall units below.

Base Installation

5

TECHNICAL BULLETIN

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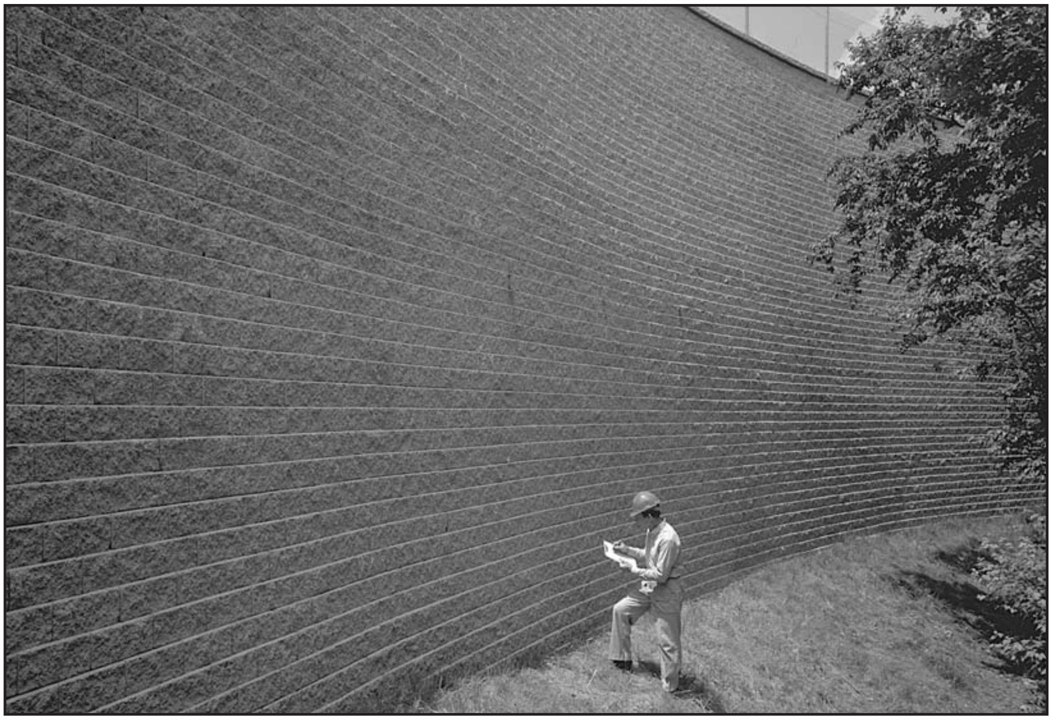

The unique beauty and structural integrity of VERSA-LOK® Retaining Wall Systems starts at the base. Proper installation of the wall base is critical to the stability and appearance of VERSA-LOK walls. Careful base preparation also speeds upper wall installation and helps prevent alignment problems. VERSA-LOK retaining walls are placed on granular leveling pads embedded slightly below grade. Rigid concrete footings extending below frost depths are not needed or recommended. The flexibility of the leveling pads and the mortarless units accommodates freeze/thaw cycles without damage to the wall.

This bulletin provides a general overview of VERSA-LOK wall base components and installation. However, none of the information presented here should be interpreted as final construction details. Site conditions and design considerations will vary. A qualified professional engineer should prepare a final, project-specific design based on actual site conditions.

FOUNDATION SOIL

Foundation soil below the leveling pad and wall backfill must provide sufficient capacity to support the weight of the wall system. If the foundation material is fine soil (clay and silt) it should be stiff. If the foundation soil is coarse-grained (sand or gravel) it should be dense. Soft, loose, compressible, wet, frozen, or organic topsoils are not acceptable for foundation soils. A geotechnical engineer should evaluate and determine the bearing capacity of foundation soils and any needed modifications.

Any unacceptable material should be excavated and replaced with properly compacted backfill. If the wall base is built over existing fill, such as utility trench backfill or side cast fill along basement walls, ensure this fill is properly compacted or replace it.

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EMBEDMENT

Burying the base of the wall provides enhanced stability and long-term protection for the leveling pad. However, VERSA-LOK® walls do not need to be embedded below seasonal frost depths. Because VERSA-LOK units are installed without mortar, they are free to move slightly in relation to each other and can accommodate freeze/thaw cycles.

VERSA-LOK retaining walls typically have one-tenth of the exposed height embedded below grade. For example, a wall with ten feet of exposed wall height (H_e) should have one foot (two courses) of units buried below grade, making the total wall height 11 feet (Figure 1). Short walls usually have a minimum of 0.5 feet (one course) embedded. The amount of embedment should be increased for walls with slopes at the toe and for special conditions such as poor foundation soils or water applications. The wall design engineer or soils engineer (or both) should address the needed embedment.

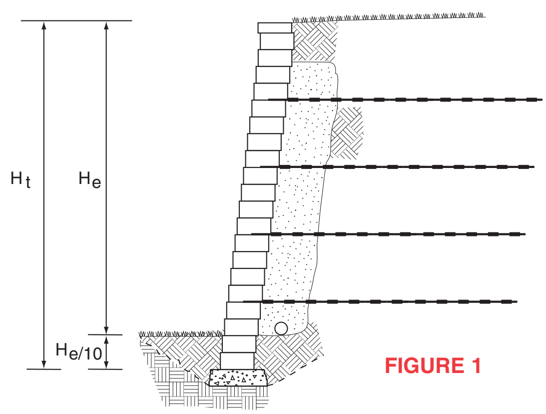


FIGURE 1

LEVELING PAD

VERSA-LOK walls are installed on granular leveling pads that distribute the weight of the wall units evenly and provide stiff, yet somewhat flexible, working pads. Leveling pads should be a minimum of six inches thick and 24 inches wide and usually consist of road base aggregate—a crushed gravel with some sand and a small amount of fine soil (Figure 2).

Rigid, high-strength concrete footings are generally not needed or recommended. The leveling pad should be flexible to move with freeze/thaw cycles. If concrete is used for a leveling pad, it should be a lean mix (200-300 psi) and no more than two to three inches thick. Concrete can be difficult to adjust, so make sure a concrete pad is exactly level before it sets. In rare situations where a rigid, steel-reinforced concrete footing is required, place it below frost depth.

INSTALLATION OF BASE

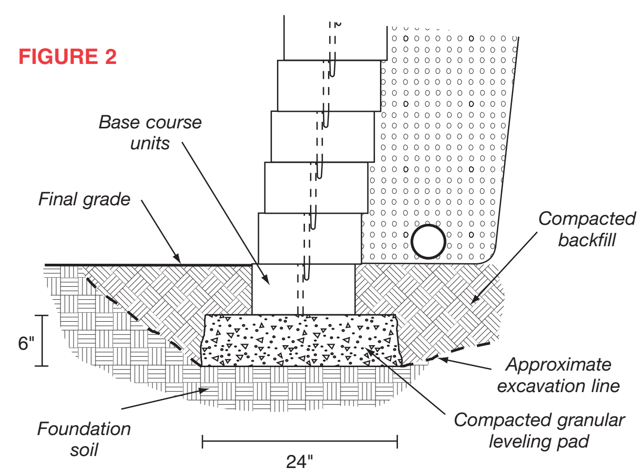
LAYOUT OF WALL BASE

Carefully plan the location and alignment of the wall base to ensure the top of the wall will be at the desired location. Start base layout at the lowest point and work up. Allow room for the 3/4-inch setback in each six-inch high course by placing the wall base forward of the planned top-of-wall alignment.

Be sure to "backward" plan from the top of the wall when installing outside (convex) curves. As additional courses are added, the setback in each course will reduce the curve radius. It may shrink to less than the minimum (8 feet) without proper planning. See Technical Bulletin No. 3 for more information.

If the final grade along the front of the wall changes elevations, the wall base may be stepped up in six-inch increments to match the grade change. Plan to step up often enough to avoid burying extra units while maintaining required embedment (Figure 3). Be sure the base layout accounts for the 3/4-inch horizontal setback that occurs at each six-inch-high step up of the base.

FIGURE 2



Stepped Base

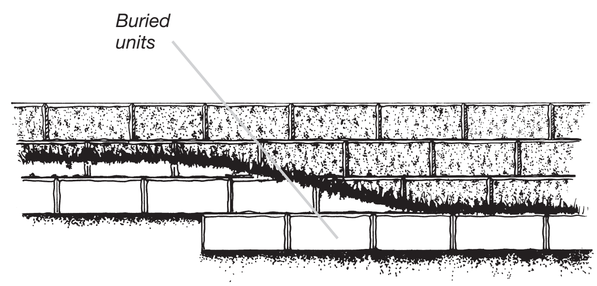


FIGURE 3

EXCAVATION

Before excavating for the wall base, confirm location of all utility lines and other underground structures and take proper precautions when digging. Excavate a trench just deep enough to accommodate the leveling pad and wall embedment. Be sure any poor soils unacceptable as foundation material, such as organic topsoil, are also excavated, replaced and compacted.

1. *Set and level metal screed forms.*

2. *Compact foundation (native) soil.*

3. *Fill forms with granular base material.*

LEVELING PAD CONSTRUCTION

Place and compact granular leveling pad material to a smooth and level surface. Always start at the lowest level and work up. A thin layer of sand may be used at the top of the pad for final leveling.

To quickly construct long sections of leveling pad, create forms by staking and leveling rectangular metal tubing (screed rails) at the back and front of the planned pad alignment. Place gravel up to the top of forms and compact. After compacting, fill the remaining space with sand and screed off the excess material. *(See photos 1-5)*

4. *Compact leveling pad granular material.*

5. *Screed sand for final leveling of pad.*

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TECHNICAL BULLETIN

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U.S. Patent D319,885,
U.S. Patent D321,060,
U.S. Patent D341,215,
U.S. Patent D346,667,
U.S. Patent D378,702,
U.S. Patent D391,376,
U.S. Patent D430,680,
U.S. Patent D435,302,
U.S. Patent D439,678,
U.S. Patent D452,332,
U.S. Patent D458,387,
U.S. Patent 6,488,448 and
other U.S. patents pending;

Canadian Industrial Design Registration No. 63929, No. 71472, No. 73910, No. 73911, No. 73912, No. 77816, No. 79058, No. 82288, and No. 89084.

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INSTALLATION OF BASE COURSE UNITS

Starting at the lowest level, center the first course of units on the leveling pad. Place the entire length of the lowest course before proceeding to the next course. Begin the base course at any corner and work away from there. Place the units side by side with the front joints tight. For easier placement of base course units, use a VERSA-Lifter® to hold the units while lowering them onto the leveling pad. This helps avoid disturbance of the pad which may occur when placing units by hand.

Align the wall along the backs of units, not the irregular split front faces. For alignment tips on curves and corners, see Technical Bulletin #3. Level each unit from front to rear, side to side, and with adjacent units with a level that is at least four-feet long. Tap high points with a hard rubber mallet or a hand tamper. Be patient and ensure the base course is level; any minor unevenness at the base will be amplified and difficult to correct after several courses are installed.

After the entire base course is installed, place and compact soil fill behind the units. Also replace any over-excavated soil in front of the units and compact. This helps keep the units in place during further construction activity. Backfill around the embedded units should be native soil. Do not place drainage aggregate behind embedded course(s). Drainage aggregate should not extend lower than the planned final grade in front of the wall.

6. Use a VERSA-Lifter® to aid in lifting and placing base course units.

7. Use a long level to maintain consistency unit to unit.

8. Step-up leveling pad and base course in six-inch increments when grade changes.

Freestanding Walls, Columns, and Vertical Walls

6

TECHNICAL BULLETIN

This Technical Bulletin is the sixth in a series of informational papers that provide specific application ideas and installation tips for VERSA-LOK® Retaining Wall Systems. Additional information is available in our *Design & Installation Guidelines.*

FREESTANDING WALLS

Solid VERSA-LOK® Standard units do it all, including easy-to-install freestanding walls with the same natural, classic look as VERSA-LOK Standard retaining walls. VERSA-LOK units are easily modified by splitting off the back of the units. From these split units, installers can build freestanding walls with textured faces on both sides. Unlike retaining walls, freestanding walls are exposed on both sides and do not retain soil. Designers can use VERSA-LOK freestanding walls for stand-alone walls set directly at grade (Figure 1) or for parapets, extending above the top of retaining walls (Figure 2).

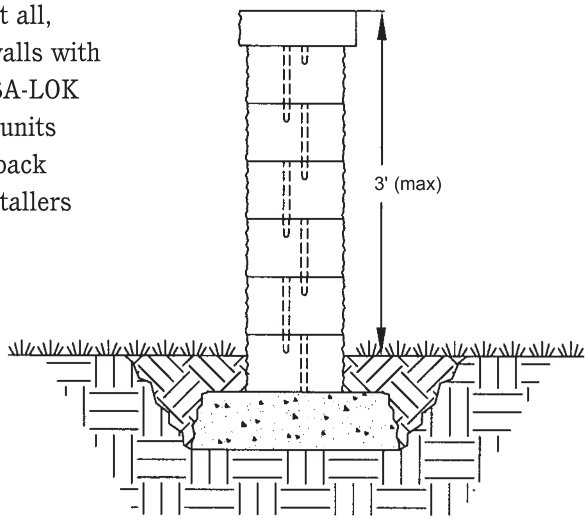

FIGURE 1

Similar to VERSA-LOK retaining walls, freestanding wall units inter-connect with pins and rest on granular leveling pads. No mortar or concrete footings are needed. The weight of freestanding units and the pinned unit connection provide wall stability. Stand-alone freestanding walls are stable up to three feet. Freestanding walls used as parapets at the top of retaining walls are stable up to 2.5 feet.

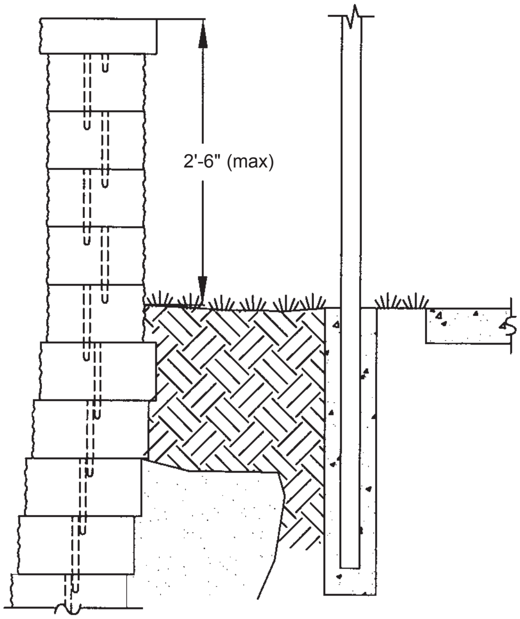

FIGURE 2

While VERSA-LOK freestanding walls provide excellent aesthetic options and visual screening, do not rely on them or use them to resist loads such as pedestrian or vehicular traffic. To protect against lateral loads, engineer-designed structures (like guardrails or concrete traffic barriers) should be installed behind walls. For more information, see Technical Bulletin No. 8 – Fences, Railings, & Traffic Barriers.

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SPLITTING UNITS FOR FREESTANDING WALLS

Splitting on the groove that extends across the back of a VERSA-LOK® Standard unit (Figure 3) creates a textured split-face on the back of the unit, similar to the appearance on the front face. Because this split is two inches from the back, it reduces the original 12-inch-deep unit to ten-inches deep. For consistent splits, a mechanical splitter must be used. In some cases, a supplier may be able to provide pre-split units for an added charge. Check with your local VERSA-LOK supplier.

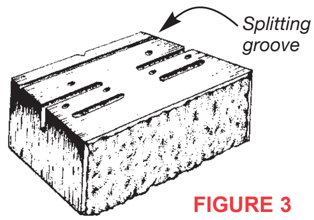

FIGURE 3

STRAIGHT FREESTANDING WALLS

Using these back-split units, install straight freestanding walls by aligning the rear split face of one unit with the front face of the units placed next to it (Figure 4).

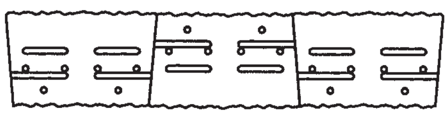

FIGURE 4

Continue alternating the direction units face as you place the remainder of units for the first course. Place succeeding courses in the same way but shift each course halfway over the units below (half-bond). Pin units using the center holes and front slots (Figure 5).

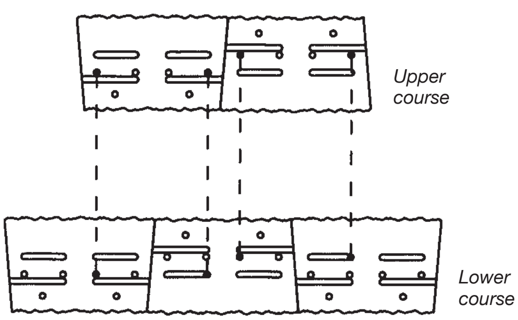

FIGURE 5

In addition to pinning, VERSA-LOK Concrete Adhesive is used between each course to help stabilize the wall. However, do not stop using pins. Full curing of adhesive may take several days. Without pins, wall units may slide as work progresses.

CURVED FREESTANDING WALLS

Create curved freestanding walls by placing the back-split units tightly next to each other, with the front of the units all on the same side (Figure 6). This creates about an eight-foot radius curve, measured from the front of the units. (No other radius is possible without gapping units or extensive saw-cutting.) Place succeeding courses the same way, with the next course of units shifted halfway over the units below (half-bond).

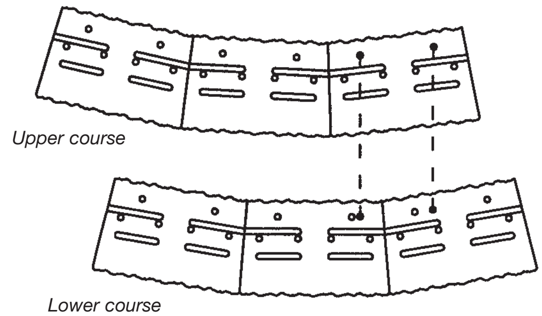

FIGURE 6

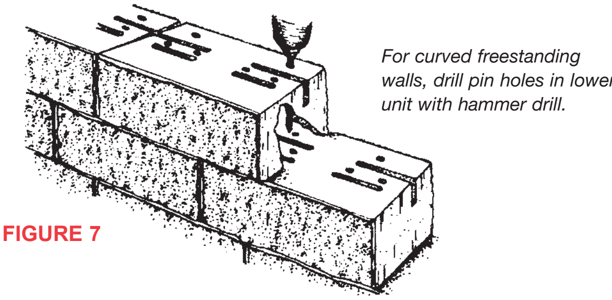

FIGURE 7

Pinning curved freestanding walls requires drilling receiving pinholes with a hammer drill (Figure 7). Pass a 1/2-inch-diameter by ten-inch-long masonry bit through the rear holes in upper units and bore two-inch deep holes into the lower units. Pin through the rear holes of the upper units into the newly drilled holes in lower units. Also use VERSA-LOK Concrete Adhesive on each course to help stabilize wall. Transitions from curved to straight walls or serpentine curves require saw-cutting units.

CAPS FOR FREESTANDING WALLS

There are two suggested methods for capping freestanding walls. The standard method uses VERSA-LOK® Caps without modification. Place these 12-inch-deep caps so they overhang both sides of the wall units by one inch. VERSA-LOK Caps have a split face only on the front, so this method leaves one side of the cap with a smooth face (Figure 8).

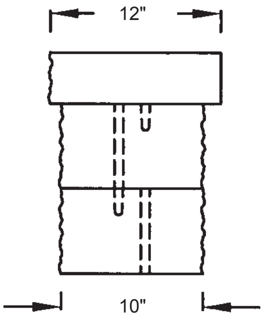

FIGURE 8

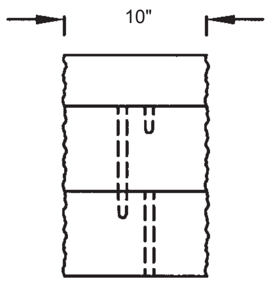

FIGURE 9

An alternate capping method provides textured faces on both sides of the cap but eliminates overhang of the cap. Using a mechanical splitter, split off the back two inches of the caps (a minimum two-inch split is needed to achieve a proper split). Place these modified caps with the split-faces of the caps flush with the faces of the wall units (Figure 9).

For straight freestanding walls, alternately place A and B cap units along the length of the wall. For curved walls, place all A caps or all B caps. The radius of either A or B caps is slightly different than the eight-foot radius of the wall units, so some cutting of caps on curved walls is needed to create a completely gap-free appearance. Arrange all cap units first, then secure with VERSA-LOK Concrete Adhesive. For more information on capping, see Technical Bulletin No. 4 – Caps.

ENDS FOR FREESTANDING WALLS

The end of a freestanding wall can be nicely finished with textured, split-faces that match the faces on the front and back of the wall. Split the modified freestanding wall units between the slots (Figure 10). This split should be as close to the slots on one side as possible, without exposing these slots. Place these split units at the end of each course, alternately using the narrower-split and then the wider-split units on succeeding courses. For the courses ending with the wider-split units, place a saw-cut partial unit next to the end unit to get back on half-bond (Figure 11).

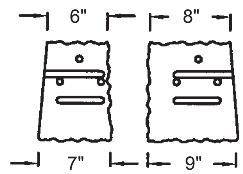

FIGURE 10

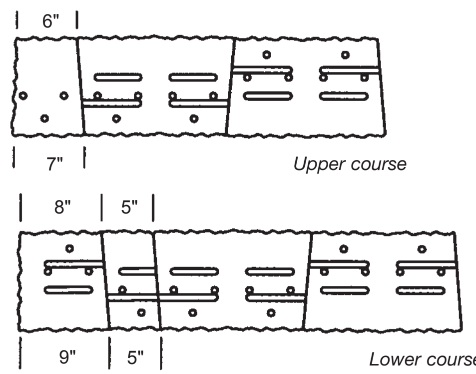

FIGURE 11

COLUMNS

A wide variety of attractive columns can be easily installed from VERSA-LOK Standard units. Like VERSA-LOK retaining walls, columns less than four feet high can be stacked without mortar, placed on granular leveling pads, and do not require footings below frost (Figure 12). Generally, columns should have a minimum of one course of units (six inches) buried below grade. VERSA-LOK columns typically have a vertical face (no setback).

While VERSA-LOK columns make excellent decorative landscape fixtures, they should not be used to support loads or exceed four feet in height without structural reinforcement designed by a qualified engineer

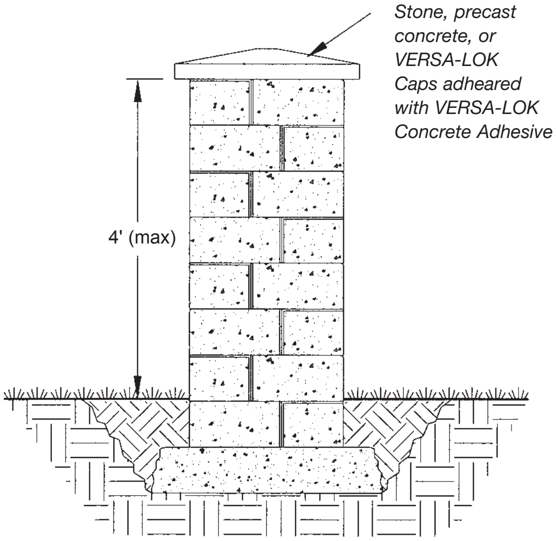

FIGURE 12

A 20-inch-square column is created simply by splitting VERSA-LOK® Standard units into half-units and placing a half-unit at each of the four corners of the column (Figure 13). For each succeeding course, shift the bond so the half-units being placed overlap the half-units below (Figure 14). One simple way to do this is to split four VERSA-LOK Standard units at a time. Place the four, right-side half-units first and then, for the next course, place the four, left-side half-units.

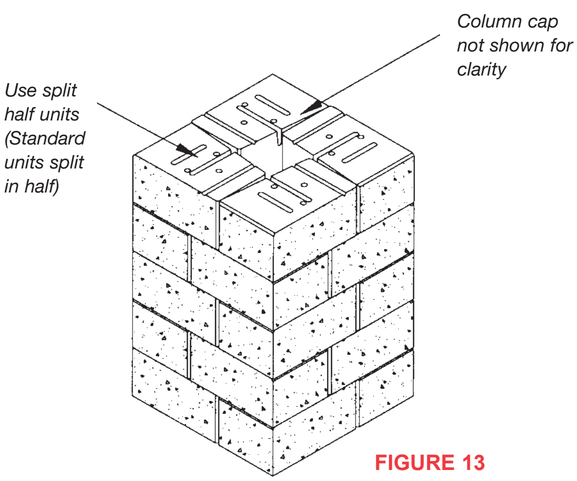

FIGURE 13

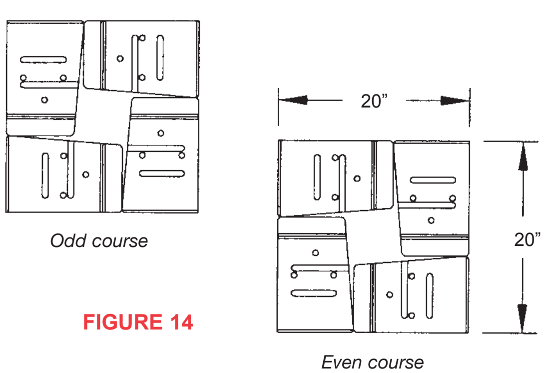

FIGURE 14

A 36-inch-square column also can be easily installed by combining four half-units with four whole units for each course of the column. Each succeeding course of units should be shifted so units placed overlap the units below (Figure 15). Building columns of other sizes is also possible by placing half-units at the corners and combinations of whole or saw-cut partial units between the corner, half-units.

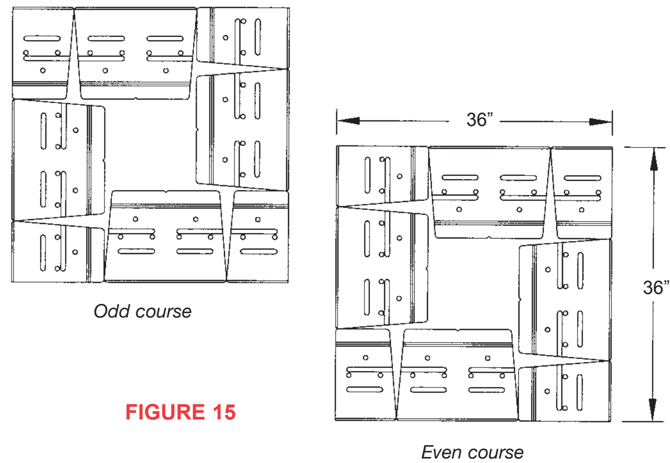

FIGURE 15

Units placed in columns will not pin. So each course of units should be adhered to the units below with VERSA-LOK Concrete Adhesive. Do not use rigid adhesive or mortars for VERSA-LOK columns on flexible granular pads, they will shift slightly causing rigid adhesives to fail.

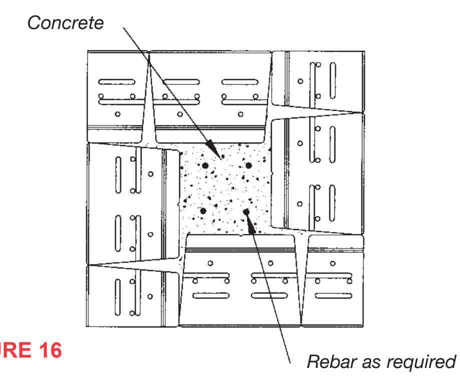

FIGURE 16

Columns can be built taller than four-feet-high but a taller column requires a structural footing below frost, tied to concrete and steel reinforcement within the column. The center hole of the column (behind the units) provides a space in which steel-reinforced concrete can be placed (Figure 16). Column units may require temporary bracing during placement of concrete within the column until the concrete sets. A qualified professional Civil Engineer should provide a design for columns over four feet high.

COLUMNS WITH WALLS

VERSA-LOK® columns can be combined with VERSA-LOK freestanding walls to create attractive landscaping elements. Also, columns provide an aesthetic way to create a corner within a freestanding wall (Figure 17). The suggested way to incorporate a column with a freestanding wall is to saw-cut the units in the freestanding wall to butt against the adjacent column. With proper design, columns can also be used as highlight elements or corner features within VERSA-LOK retaining walls.

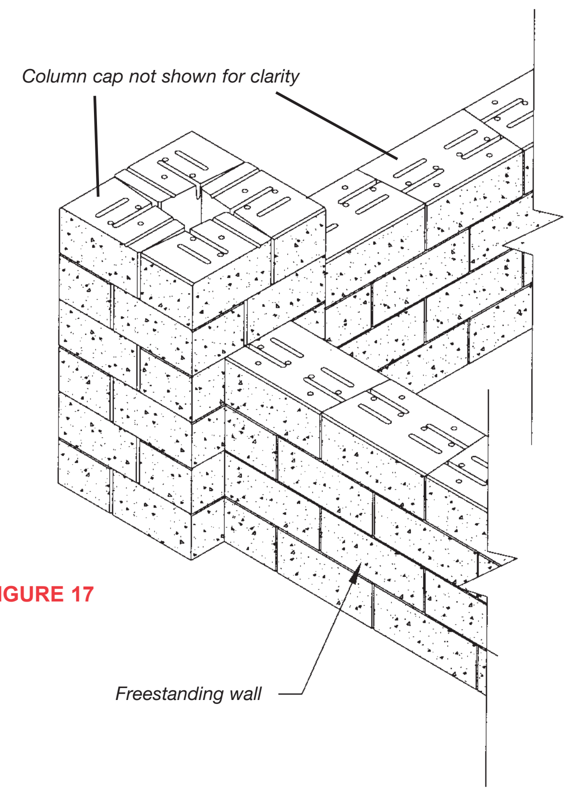

FIGURE 17

VERTICAL RETAINING WALLS

On tight project sites, building vertical VERSA-LOK retaining walls can save valuable space at the top of the wall. However, there are several reasons installing walls with the standard 3/4-inch setback may be preferable, when space allows. Vertical walls are not as stable as setback walls because they do not lean back into the soil. The maximum unreinforced vertical retaining wall height is three feet and may be lower depending on site and soil conditions. Vertical walls also eliminate the aesthetically pleasing horizontal lines created by the standard setbacks. Installers should use special care when building vertical walls to avoid moving units during construction. Any deviation in alignment of a vertical wall is very visible and also may affect wall stability. Also, reinforced vertical walls require more geogrid, better backfill, and more installation time than setback walls. While vertical walls are more difficult to pin properly, using VERSA-LOK Concrete Adhesive in place of pins is not recommended. The adhesive may take several days to fully cure and retained soil pressures may slide units out of place during, or shortly after, construction.

STRAIGHT VERTICAL RETAINING WALLS

Straight vertical walls are installed on half-bond (upper unit halfway over lower units) so the rear pin holes line up. Do not build vertical walls on stacked-bond (upper units directly over lower units). After laying the base course, insert pins into all the rear holes and, using a second pin and hammer, drive the pins two to four inches into the leveling pad. Pins in the base course provide a stop, keeping pins in the units above from dropping all the way through the upper units. Lay the next course of units so the rear holes in each upper unit line up with the rear holes in both units below (Figure 18). Insert pins through upper units, into the rear holes in the units below.

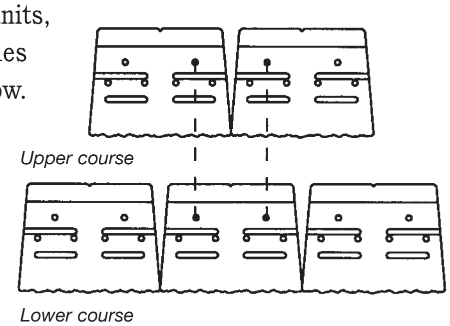

FIGURE 18

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CURVED VERTICAL RETAINING WALLS

Curved vertical walls require drilling so they can be pinned. The procedure for drilling pin holes is similar to that described previously for freestanding walls. Position upper course units on half-bond and drill through both rear holes in upper units into the lower units to create receiving pin holes (Figure 19). Pin units using these holes.

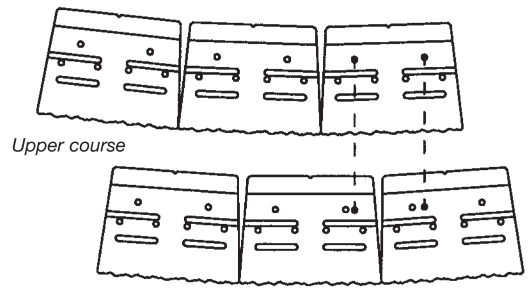


FIGURE 19

CORNERS FOR VERTICAL RETAINING WALLS

Inside and outside corners for vertical retaining walls are installed similarly to corners for setback walls. However, to maintain the half-bond needed for vertical walls, additional saw-cut partial units must be installed next to the corner units. For an outside 90-degree corner, lay a split half-unit at the corner and then place a saw-cut, 12-inch-wide, partial unit next to it (Figure 20). Corner and partial units should be secured with VERSA-LOK® Concrete Adhesive or drilled and pinned.

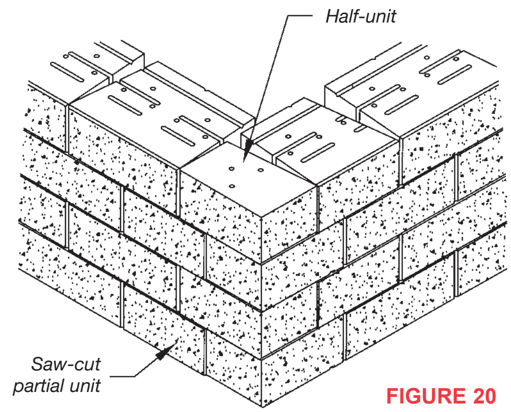


FIGURE 20

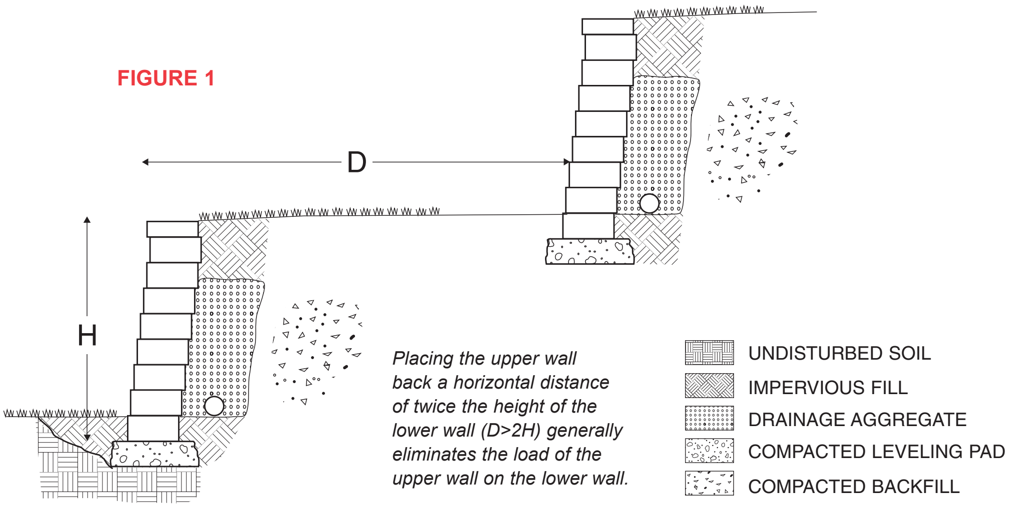
7

Tiered Walls

A tiered retaining wall system is a series of two or more stacked walls, each higher wall set back from the underlying wall. When designed properly, they not only retain soil and support loads, but also deliver an attractive appearance and provide room for plantings.

When segmental retaining walls are tiered, the upper walls may exert extra loading on the underlying wall(s), necessitating special designs. When an upper-tier wall is placed within a horizontal distance less than twice the height of the underlying wall, the upper wall will apply a surcharge load on the lower wall (Figure 1). The wall design engineer must carefully analyze the site soil conditions and spacing between walls to determine overall stability of the entire tiered-wall system.

FIGURE 1



TECHNICAL BULLETIN

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ENGINEERING TIERED WALLS

Tiered walls are often more difficult to estimate and design than conventional single walls. Most single walls less than 4 feet high do not require geogrid reinforcement or engineering. In contrast, geogrid for tiered walls cannot be estimated using standard design charts, and tiers are more complicated to engineer. Even short tiered walls (less than 4 feet high) may require geogrid and engineering.

If the setback between tiered walls is at least twice the height of the underlying wall, with level grades between walls, each tiered wall can be treated as a separate entity during planning and engineering. When the setback distance between tiers is less than 2:1 (horizontal:vertical), the wall design must account for additional loads applied by upper walls (Figure 1).

As with any retaining wall project, a final engineered design must be prepared by a qualified, registered civil engineer when required. In addition, tiered walls often require an analysis of the slope stability (discussion below).

SLOPE STABILITY

Slope stability is a particular concern when designing tiered walls. A slope (global) stability failure is the mass movement of retaining wall structures and adjoining soil mass. Although an individual tier may be locally stable, there is a potential for deep-seated failure extending below the bottom of tiered walls (Figures 2A and 2B) that should be addressed in wall design.

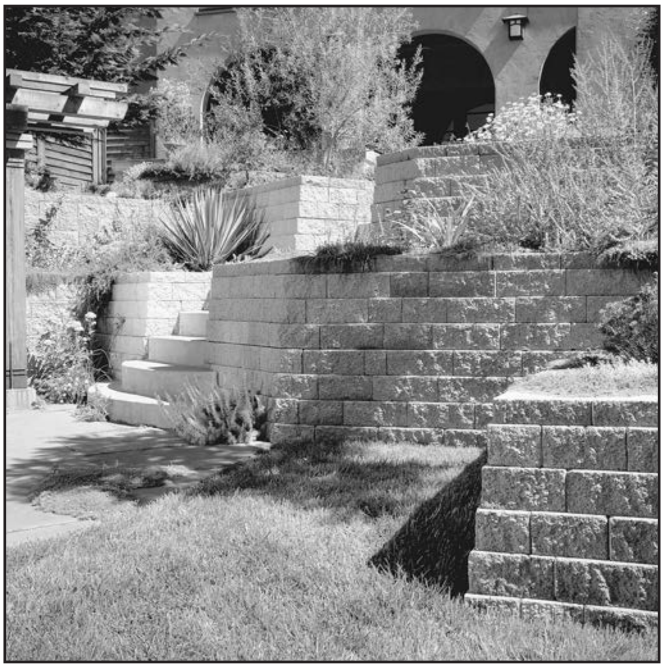
Most unreinforced soils are not stable at slopes steeper than 2:1 (horizontal:vertical). If multiple tiered walls create a grade change steeper than 2:1, there is a slope stability concern that may require additional geogrid reinforcement. A qualified engineer should review the global stability of tiered walls that are steeper than 2:1, or that have slopes at the top or bottom of the walls.

Placing multiple tiers steeper than 2:1 can cause a deep-seated slope failure (Figure 2A).

Lengthening geogrid can address slope stability concerns (Figure 2B).

FOUNDATIONS AND COMPACTION

When building tiered walls, upper walls are often supported on the backfill behind lower walls. It is critical to carefully compact the lower-wall backfill to ensure the upper walls do not settle or overturn. Wherever upper walls rest on lower-wall backfill, well-graded granular soil is the preferred backfill material. Granular soils are easier to compact properly and settle less after construction.



Tiers may cost more to install, but they deliver an added aesthetic appeal.

SLOPE STABILITY ANALYSIS

FIGURE 2A

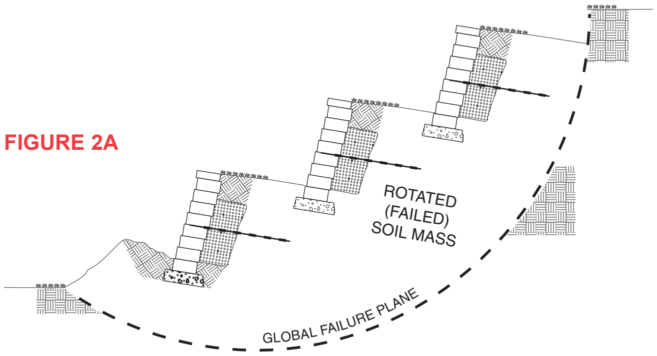
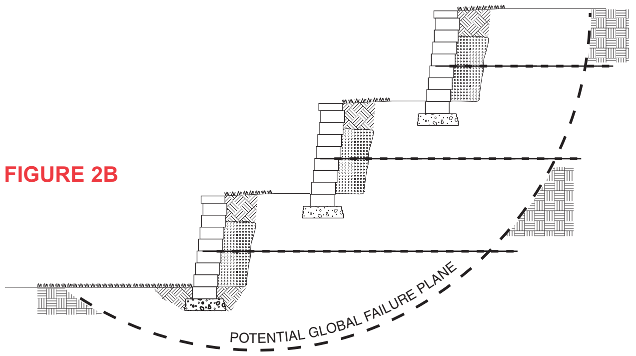


FIGURE 2B



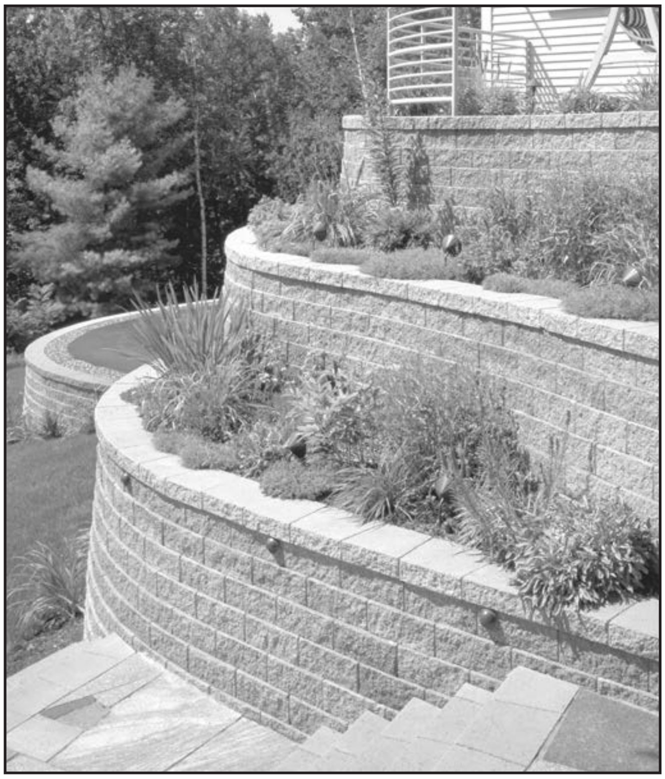
DRAINAGE

Providing proper drainage is especially important when building tiers. Any drainage problem in the upper wall(s) can compound in the lower walls. Surface drainage should be directed away from the walls by properly grading the area between the tiers and at the top of the tiers. Avoid any concentration of water behind the walls. Tiered walls should have a standard drain system that includes drainage aggregate behind all tiers. Drain pipes in upper tiers should not outlet onto lower walls, but instead should carry water away from walls.

COST EFFECTIVENESS VS. AESTHETICS

Tiers can improve aesthetics by visually breaking up a large monolithic wall. Tiered walls also create additional space for planting beds. However, more room is required and additional labor is needed to install tiered walls. The most labor-intensive part of installing a segmental wall is base preparation.

Tiered walls with setbacks of less than 2:1 (horizontal:vertical) usually require longer geogrid lengths at the bottom than single walls. This increases required excavation if the walls are cut into the existing soils. If there is room, spacing the tiers apart by more than twice the height of the lower walls minimizes the reinforcement needed, but still requires additional base preparation.



Tiered walls with plantings provide an attractive alternative to a single tall wall.

Alternatively, placing one short, unreinforced wall in front of one taller, reinforced wall provides the aesthetic advantage of tiers while reducing base preparation costs and the amount of space used when compared to a multiple-tiered wall.

SINGLE CONVENTIONAL WALL

- LEAST SPACE TO MAKE GRADE CHANGE
- LEAST ADAPTABLE TO LANDSCAPING
- LOWEST COST (SITE WORK, BASE PREPARATION)

MULTIPLE TIERS

- MOST SPACE NEEDED
- MOST ATTRACTIVE LANDSCAPING
- HIGHEST COST

ALTERNATIVE TIERED WALL

- MEDIUM SPACE NEEDS
- GOOD AESTHETICS
- MEDIUM COST

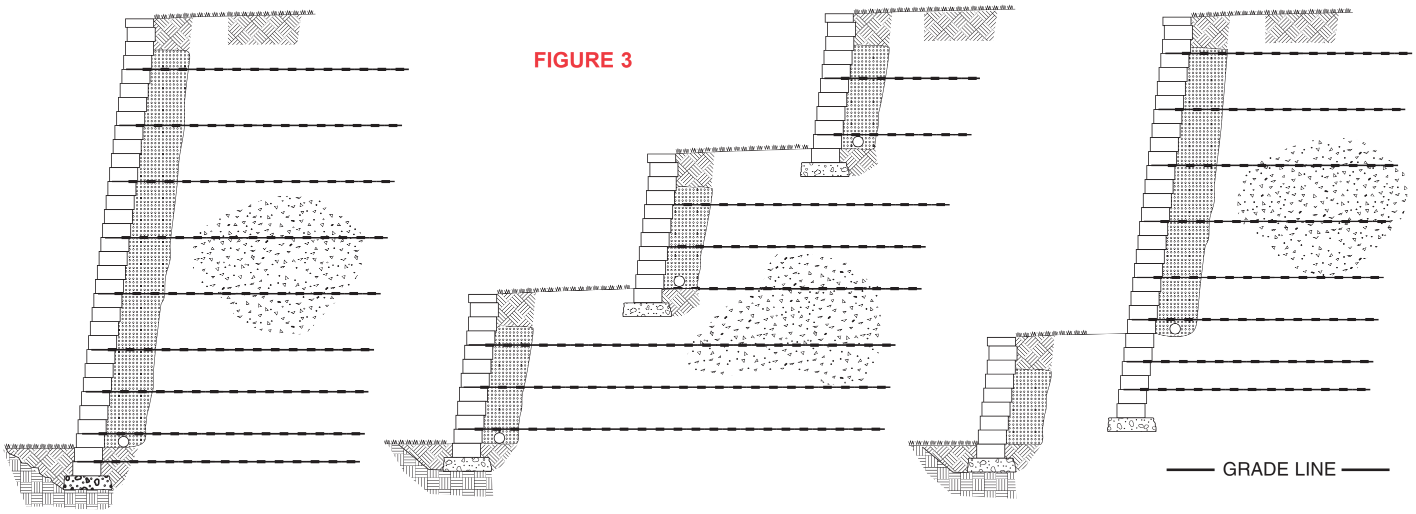


FIGURE 3

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TECHNICAL BULLETIN

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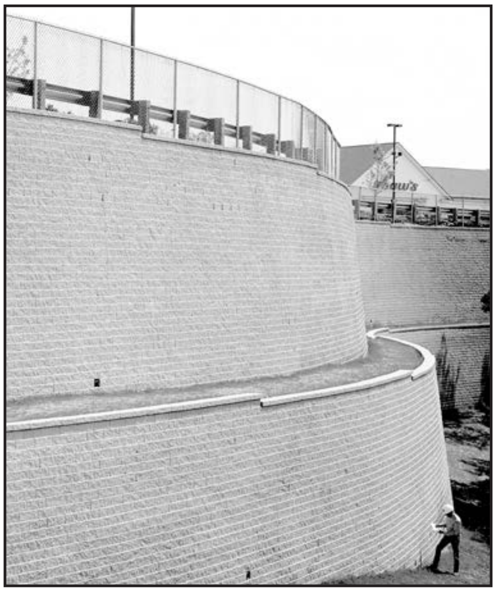
TIERED TALL WALLS

The two-tiered VERSA-LOK retaining wall shown on the right is more than 40 feet in overall height. It is set back approximately 4 feet at its midpoint to create an aesthetic "break." Both tiers were engineered with up to 25-foot lengths of geogrid reinforcement. The design of this wall is similar to that of a single 40-foot-high wall. Because setback between tiers is small, no additional length of geogrid is required. However, when an upper tier is set further back, but still not reaching the point of "no influence" (twice the height of lower wall), the walls are more prone to sliding at the base. Then the bottom wall would require longer geogrid layers than a single tall wall.

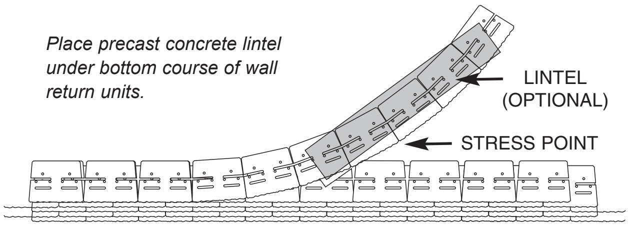


Geosynthetics and compacted soil combine to create a reinforced soil structure behind each tier.

TIERED RETURNS

Often, grade changes at the top or end of a wall can be accommodated by splitting a single wall into tiered sections and turning the tier into the slope behind the main wall. At the beginning of the return, as units in the upper portion of the wall "leave" the main wall, stress is created when these units are no longer supported by the underlying wall. Settlement and/or gapping may occur at this point. This can be minimized by thoroughly compacting the fill below the return wall, and increasing the thickness of the return wall granular leveling pad. A lintel (concrete beam) extending from the main wall and placed under the units in the return wall can also be used.

FIGURE 4 Return Wall Detail



Return walls create a terraced appearance instead of a series of short steps at the top of the wall.

Fences, Railings, & Traffic Barriers

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Often fences, stair rails, guide rails, or concrete traffic barriers are needed behind a VERSA-LOK wall. With proper design and installation, a variety of structural and aesthetic features can be placed at the top of a VERSA-LOK wall.

This bulletin provides a general discussion regarding the design and installation of fences and railings. However, conditions and loadings vary with each project and these guidelines are not intended as construction drawings for any specific project. The user is responsible for complying with all applicable building codes and obtaining a final, project-specific design prepared by a qualified professional engineer for a wall and any appurtenant structures.

FENCES

When there is sufficient space, the easiest and most cost-effective way to install fences above VERSA-LOK walls is to place them several feet behind walls. With sufficient fence post depth and setback, the soil can provide a stable foundation. Separating fence posts from a wall also keeps wall movement from affecting the fence. While a minimum post depth of 30 inches is suggested, the embedment and distance behind the wall needed to create a stable post foundation varies and depends on the soil conditions.

When a fence is set back behind a wall, installers can dig or drill post holes after the wall is completed or they can install posts during wall construction. One option is to create post holes during wall construction by placing cylindrical tube forms at planned post locations and backfilling soil around them. After completing the wall, the tubes are filled with concrete and the fence posts set in the concrete (Figure 1).

TECHNICAL BULLETIN

This Technical Bulletin is the eighth in a series of informational papers that provide specific application ideas and installation tips for VERSA-LOK® Retaining Wall Systems. Additional information is available in our *Design & Installation Guidelines.*

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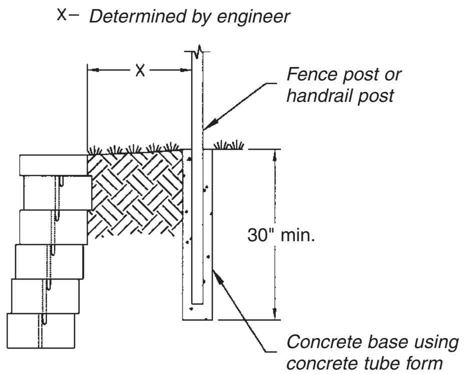
FIGURE 1 **Post Detail — Typical Section Handrail or Fence Post (Set back from wall)**



When there is not enough room to set fence posts behind walls, they can be installed within top wall units prior to backfilling behind the wall. Break off the backs of the top few units to create room for the post. Cut or core the cap units to neatly receive posts (Figures 2 and 3). The fence should be flexible enough to accommodate differential movement between the units and the fence.

Placing posts near the front of a wall decreases the fence's foundation support. To improve stability to the post, the concrete foundation should be enlarged, extended behind the wall and reinforced with steel rebar (Figures 2 and 3). The needed depth, extension length and rebar placement will vary depending on conditions and loading.

FIGURE 2 **Post Detail — Section A-A Typical Handrail or Fence Post (No Setback)**

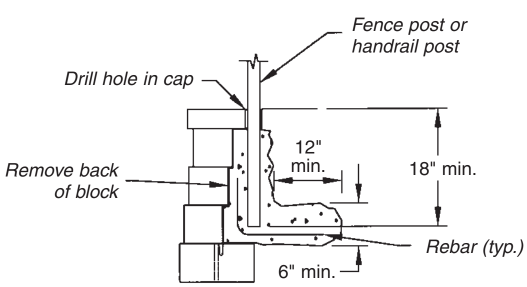
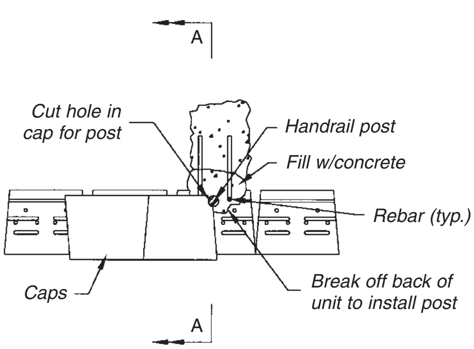


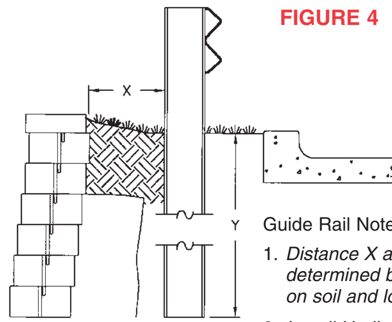
FIGURE 3 **Post Detail — Typical Plan Handrail or Fence Post (No Setback)**



GUIDE RAILS

With proper design, guide rails can be used behind VERSA-LOK walls. For proper support, place guide rails several feet behind the wall units (Figure 4). The setback and embedment depth of the guide rail will vary with conditions and loading. For highway loading, AASHTO recommends an embedment depth of 5 feet. Like fence posts, guide rails can be placed in cylindrical concrete tube forms placed during wall backfill.

FIGURE 4 **Guide Rail Detail Typical Section**



Guide Rail Notes:

1. *Distance X and Y to be determined by engineer based on soil and loading conditions.*
2. *Install H-pile or wood post as per manufacturer's recommendations.*

POSTS PENETRATING GEOGRID

For walls requiring soil reinforcement, fence and guide rail posts will often extend below the top layer or two of geogrid. Often the geogrid can be cut to fit around the planned post locations. Usually the top layers of geogrid can accommodate small intrusions while still maintaining overall tensile strength. However, the area cut from the geogrid should be no more than the minimum needed to fit the post. The wall design engineer must evaluate any planned post intrusions into geogrid layers to ensure they do not reduce strengths below needed minimums. Augering or driving through backfilled geogrid after wall construction is generally not suggested because it may excessively disturb or pull geogrid from the soil or the wall units.

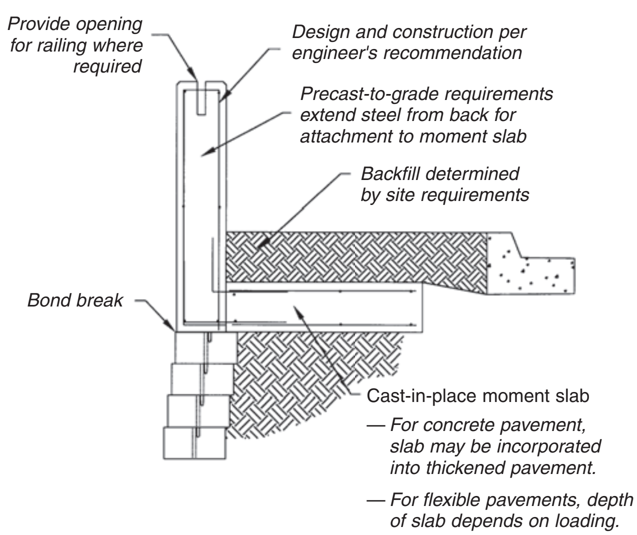
When space allows, fences and railings should be placed several feet behind VERSA-LOK walls.

CONCRETE TRAFFIC BARRIERS

When there is no room to set guide rails behind a wall, traffic barriers can be placed directly on top of a wall. These can be cast-in-place concrete or precast barriers (such as Jersey barriers) or a combination of both. Concrete barriers should be designed for stability, independent of the wall. The foundation can be extended behind the wall (moment slab) to act as cantilevered resistance to lateral and overturning loads (Figure 5).

A qualified engineer must design traffic barriers on a project-specific basis. Reinforcing steel, barrier size, and geometry will vary with site conditions and loading. Other design considerations include the need for control joints, expansion joints and bond breaks to address differential movement between the barrier and the retaining wall. During concrete placement for cast-in-place barriers, temporary bracing of the retaining wall may also be required.

FIGURE 5 Coping Detail — Traffic Barrier Section



When there is no room to set guide rails behind a wall, traffic barriers can be placed directly on top of a wall.

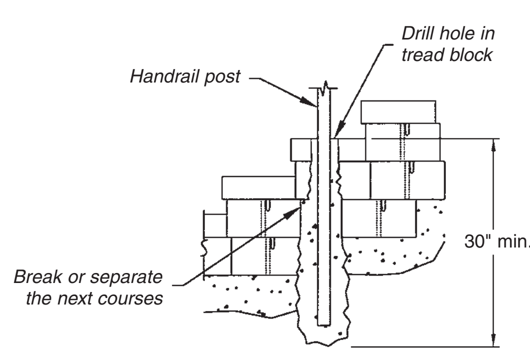
VERSA-LOK units are adaptable to various stair-rail anchoring options.

STAIR RAILS

VERSA-LOK stairs can accommodate a variety of railings with proper design, including railings anchored just above and below steps, into side wall units, or into step risers. Solid VERSA-LOK units allow use of several common techniques for attaching railings to concrete, including fasteners that embed in polymer, grout or mortar, or anchors that cut threads into the concrete. The appropriate fastener varies with loading and site conditions. Refer to the fastener manufacturer's and wall design engineer's recommendations.

When practical, spanning railings from landing to landing and placing posts directly into the soil is usually the easiest way to provide a stable foundation for stair railings. When stairs have numerous risers and spanning is not practical, railings can be attached to the units in the side walls. When there are no side walls, rail posts can be placed through the step units (Figure 6). Step units can be split or cut to extend post hole at least 30 inches deep (more depth may be needed depending on loading). The post hole should be filled with concrete. Caps can be cored to receive the post neatly, if desired.

FIGURE 6 Post Detail — Typical Section
Handrail Post at Stairs



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U.S. Patent D452,332,
U.S. Patent D458,387,
U.S. Patent 6,488,448 and
other U.S. patents pending;

Canadian Industrial Design Registration No. 63929, No. 71472, No. 73910, No. 73911, No. 73912, No. 77816, No. 79058, No. 82288, and No. 89084.

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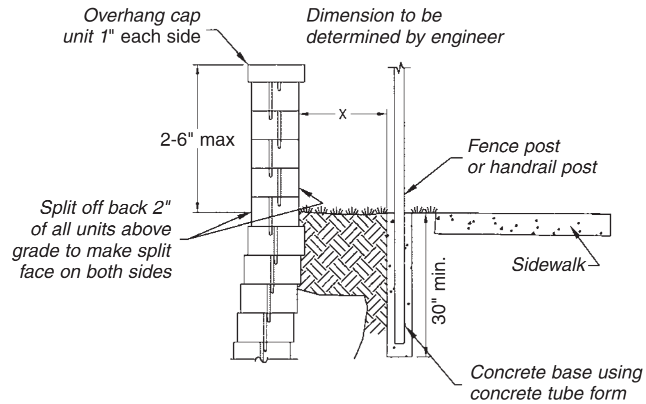
FREESTANDING WALLS

VERSA-LOK units are often used to create attractive freestanding walls that extend above the top of retaining walls. See Technical Bulletin No. 6 for more information. While these freestanding walls provide excellent aesthetics and visual screening, they should not be relied on to resist lateral loads. If pedestrian or traffic barriers are needed, independent fences or railings designed for the anticipated loads should be installed behind the freestanding wall (Figure 7).

FIGURE 7 Freestanding Wall Detail (Straight Walls Only) Typical Handrail or Fence Post



DOUBLE WALLS

When clear views over the tops of walls are desirable, lower, wider barriers sometimes are allowed as alternatives to tall fences. Depending on local building codes, back-to-back VERSA-LOK walls that are spaced far enough apart can act as a pedestrian barrier while providing room for plantings. With proper design and reinforced concrete within the double VERSA-LOK walls, they can also sometimes function as traffic barriers. Check with local codes for application and required width.

Back-to-back VERSA-LOK walls spaced far enough apart can act as pedestrian barriers while providing room for plantings.