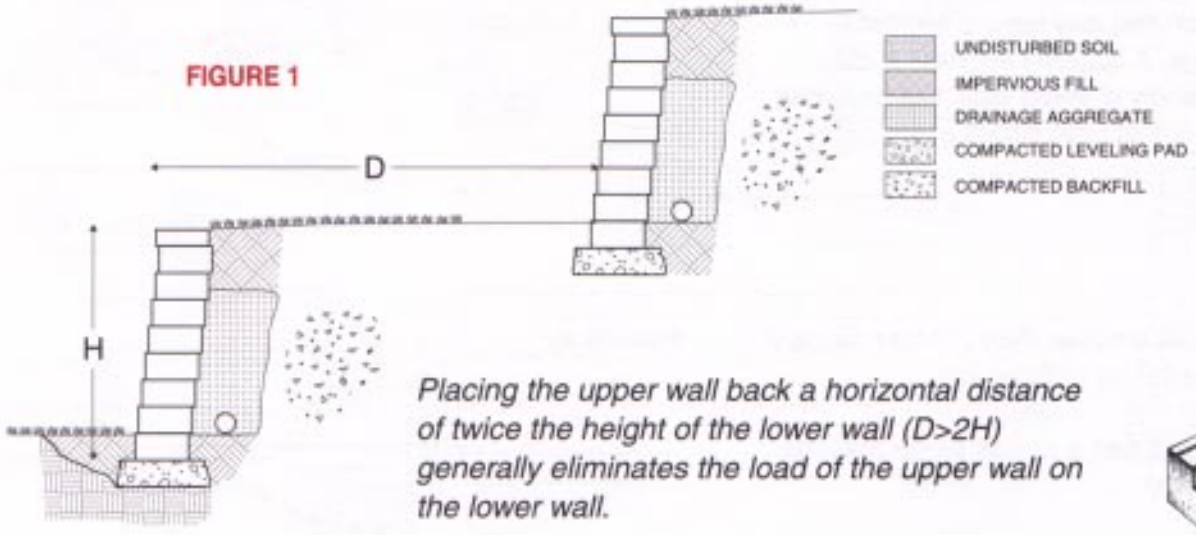
This Technical Bulletin is the seventh in a series of informational papers that provide application ideas and "how-to" tips for VERSA-LOK Retaining Wall Systems.

TIERED WALLS

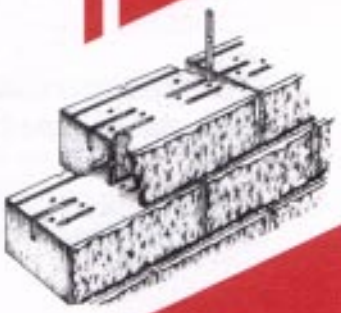
A tiered retaining wall system is a series of two or more stacked walls, each higher wall set back from the underlying wall. When designed properly, they not only retain soil and support loads, but provide aesthetic treatments.

When segmental retaining walls are tiered, the upper walls may exert extra loading on the underlying wall(s), necessitating special designs. When an upper tiered 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. 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



Placing the upper wall back a horizontal distance of twice the height of the lower wall (D>2H) generally eliminates the load of the upper wall on the lower wall.



VERSA-LOK® Retaining Wall Systems

ENGINEERING REQUIREMENTS

Tiered walls are often more difficult to estimate and design than conventional, single walls. Most single walls less than four feet high do not require geogrid reinforcement or engineering. In contrast, the geogrid requirements for tiered walls cannot be estimated using standard design charts and are more complicated to engineer. Even short tiered walls (less than four 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 when planning and engineering. When the setback distance between tiers is less than 2:1 (horizontal:vertical), the wall design must account for the additional loads applied by the upper walls.

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

SLOPE STABILITY

Slope stability is a particular concern when designing tiered walls. A slope (global) stability failure is the mass movement of the retaining wall structures and the adjoining soil mass. Although an individual tier may be locally stable, there is a potential for a deep-seated failure extending below the bottom of the tiered walls (see Figures 2a and 2b) that should be addressed in the 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 have less than a 2:1 setback, 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).

FOUNDATION EVALUATION

When low walls are founded on stiff or dense soils, local experience and visual inspection may be sufficient for foundation evaluation. On taller tiered walls, a geotechnical engineer may need to confirm that the on-site soil provides an adequate wall foundation. Generally, a site-specific geotechnical investigation is required if the foundation soils appear to be problematic, such as soft soils or non-engineered fill. When upper tiered walls will be founded on fill soils placed for the lower walls, it is critical that the fill be adequately compacted to avoid settlement of the upper walls.

Tiers may cost more to install, but provide beneficial aesthetics and room for plantings.

SLOPE STABILITY ANALYSIS

FIGURE 2a

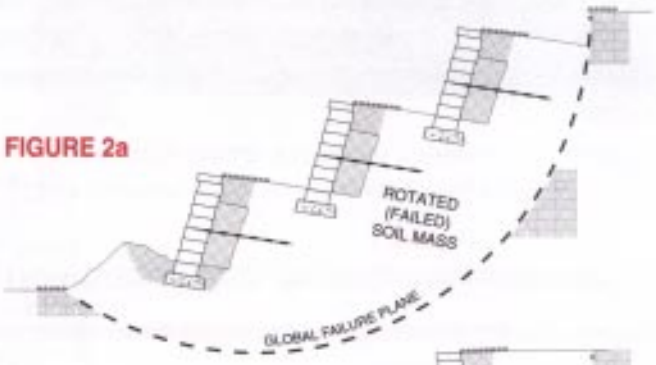
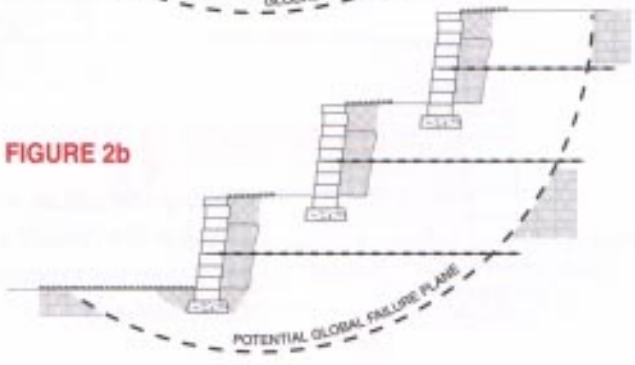


FIGURE 2b



VALUE ENGINEERING...
COST EFFECTIVENESS VS. AESTHETICS

VERSA-LOK segmental retaining walls provide a permanent, low cost, and attractive method of retaining soil. A decision as to what type of wall (single or tiered) to build can depend on whether initial cost or landscape aesthetics is the primary influence.

Tiers can yield better aesthetics than a single wall by visually breaking up a large monolithic wall. Tiered walls also create additional space for planting beds. However, more room is required at the site and the labor needed to install tiered walls is increased. The most labor-intensive part of installing a segmental wall is base preparation; tiered walls require more base preparation time than single walls.

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 being cut into the existing soils. If there is room, spacing the tiers apart by more than twice the height of the lower walls will minimize the reinforcement needed, but would still require additional base preparation. 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.

DRAINAGE

Providing proper drainage is especially important when building tiers because any drainage problem in the upper wall(s) can compound in the lower walls. Water should not be allowed to build up behind segmental retaining walls because it may exert a heavy pressure on walls that was not accounted for in the design. Surface drainage should be directed away from the walls by properly grading the area between the tiers and at the top of the tiered system. Avoid any concentration of water behind the walls. Tiered walls should have a standard drain system that includes drainage aggregate behind all the tiers. Drain pipes in the upper tiers should not outlet onto the lower walls, but instead should carry water away from the walls.

An example of tiered serpentine walls.

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

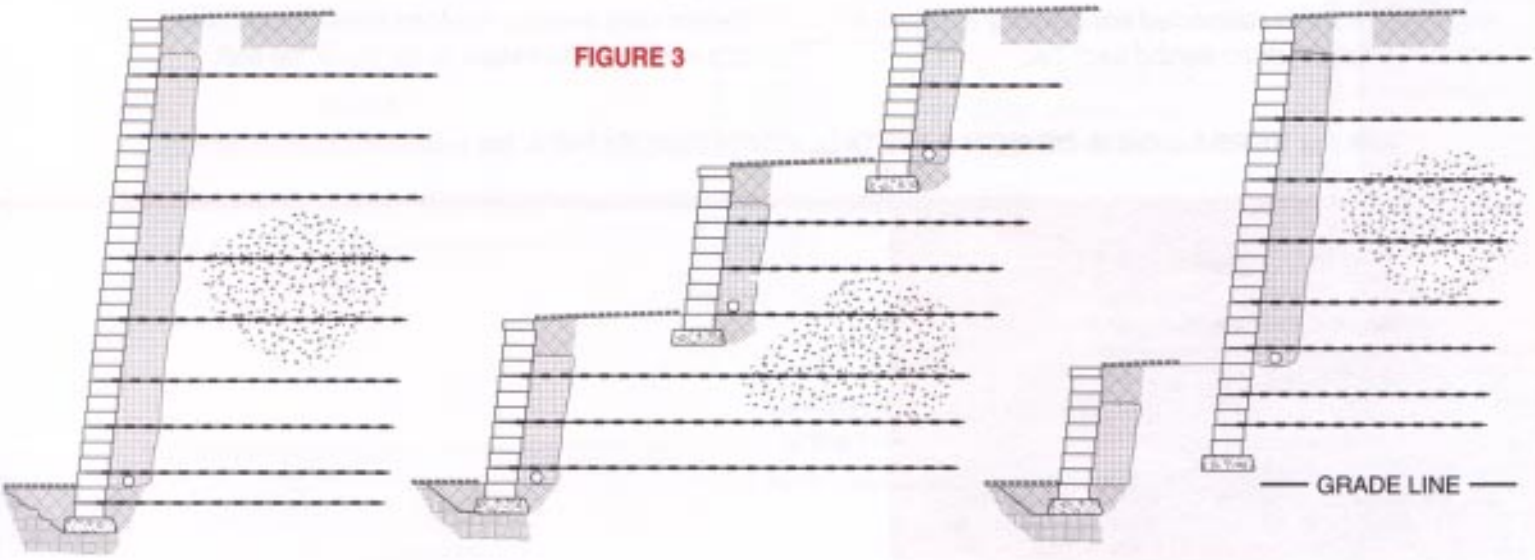


FIGURE 3

TIERED TALL WALLS

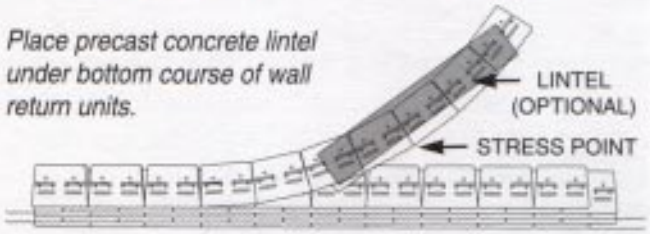
The two-tiered VERSA-LOK retaining wall shown below is over forty feet in overall height. It is set back approximately four feet at its midpoint to create an aesthetic "break." Both tiers were engineered with up to twenty-five-foot lengths of reinforcing geogrid. The design criteria for this tiered wall are almost identical to those that would be applied to a single forty-foot-high segmental retaining wall. Because of the relatively small setback between tiers, no additional layers nor lengths of geogrid were required in the bottom wall for stability. However, when an upper tier is placed further back, but still not reaching the point of "no influence" (D>2H) mentioned earlier, the wall system becomes more prone to sliding at the base. Additional length of the geogrid would then be required at the base of the bottom tier to stabilize the tiers.

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 section 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 by 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.

RETURN WALL DETAIL **FIGURE 4**



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

Ask for VERSA-LOK'S DESIGN & INSTALLATION GUIDELINES for additional information.

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