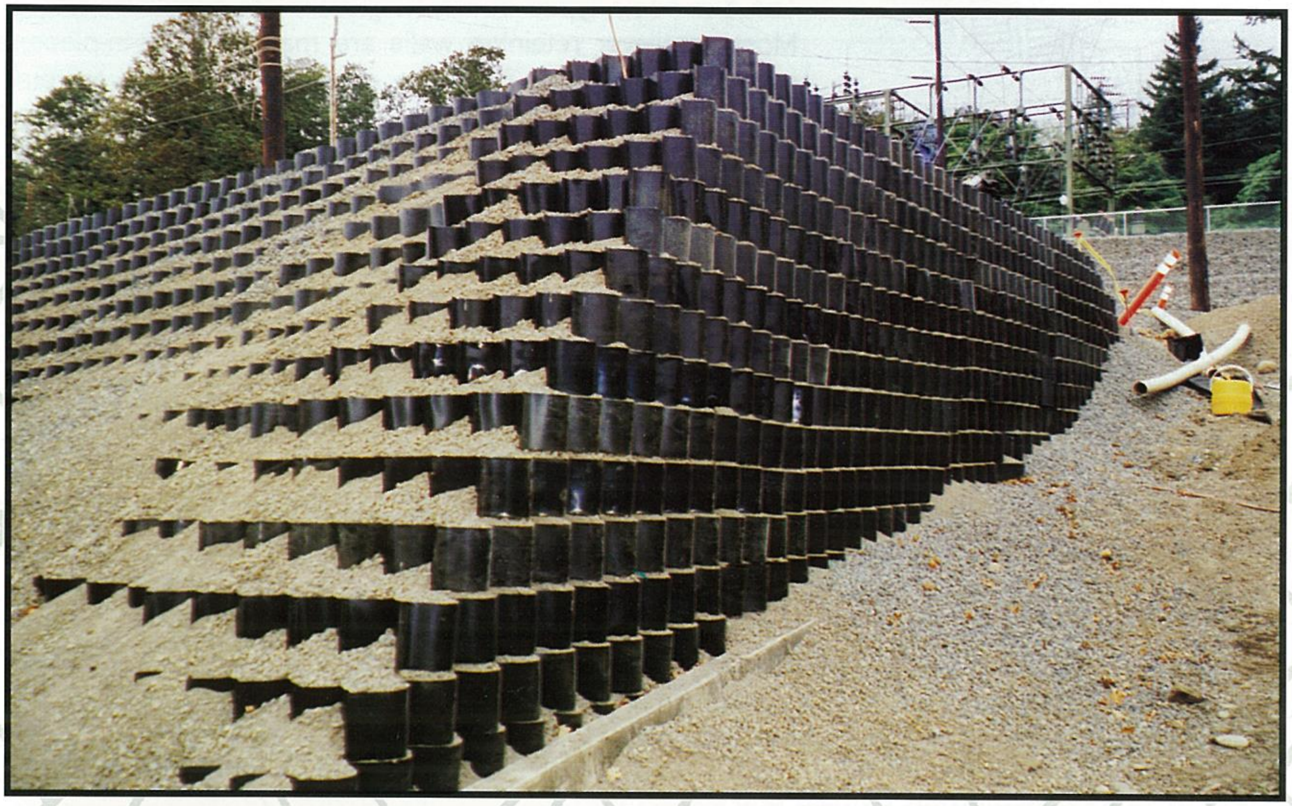
TERRACELL®

CELLULAR CONFINEMENT SYSTEM

DESIGN GUIDELINES FOR RETAINING WALLS

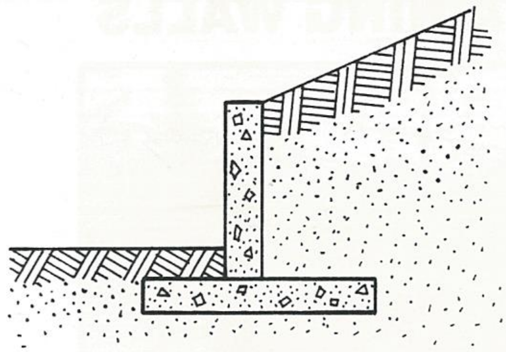


The TerraCell® Cellular Confinement System is a three-dimensional, "honeycomb" structure made from strips of polyethylene. It is designed to be an integral part of the construction of vertical or near vertical retaining walls. Use of TerraCell can be a cost-effective solution to constructing earth retention structures, in both cut and fill situations, in applications such as:

Roads and Highways
Single Family Residences • Apartment Complexes
Commercial & Industrial Developments
Bridge Abutments
Pipe End Walls
Landfills

Mechanics of Retaining Walls

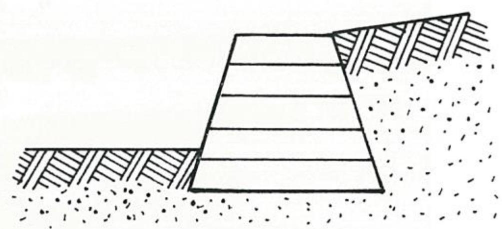
The growing scarcity of land that is affordable and easy to build upon is causing engineers, contractors, and developers to find innovative ways to use less desirable parcels of land. Areas with rough terrain and/or steep slopes were once considered as being unusable for development. Many of these areas can be made virtually flat, and thereby usable, through the employment of structures such as retaining walls and steepened slopes.



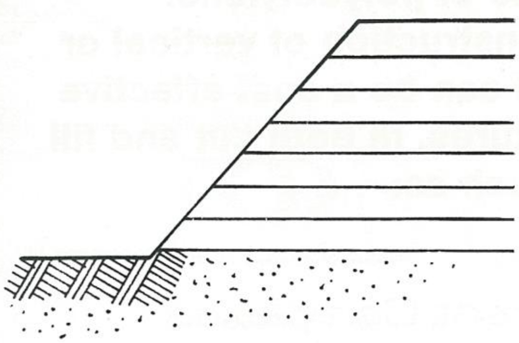
Cantilever Wall

The two basic types of retaining walls are cantilever and gravity. Most cantilever retaining walls are made of cast-in-place, steel-reinforced concrete. This type of structure is able to retain the earth behind it by virtue of its internal strength and rigidity. Reinforced concrete retaining walls are expensive to build, cannot be built in very cold weather, and are not very attractive. These walls are rigid. If stresses resulting from differential settlement exceed the strength of the concrete, cracks can develop, thereby affecting the structure's stability and appearance.

Gravity retaining walls are constructed principally of soil that is stabilized with man-made materials, such as TerraCell. This type of structure is able to retain the earth behind it by virtue of its own weight. Gravity retaining walls are typically inexpensive to build and can be built in all weather conditions. In addition, they have a degree of flexibility that allows them to adjust to small amounts of differential settlement without suffering structural damage.



Gravity Wall



Steepened Slope

TerraCell can also be used to create a steepened slope. Steepened slopes are slopes which are constructed much steeper than the soil alone would allow. A steepened slope made with TerraCell can be considered to be a retaining wall with a face inclination greater than 25°.

The TerraCell Solution

A TerraCell retaining wall or steepened slope can be constructed in almost any situation where a rapid change of grade is desired. TerraCell confines the soil or other fill material allowing the material to act as a reinforced mass.

TerraCell can be used in both fill and cut applications. In a project where the structure is built with fill material, it is usually more cost-effective to use TerraCell in conjunction with TerraGrid geogrid. TerraGrid acts as a tieback in the reinforced zone. TerraCell assumes the role of the facing element, such as concrete blocks in a modular block retaining wall. Unlike modular block, TerraCell is easy to handle, flexible, and can be planted with grass or shrubbery to give the face a natural look.

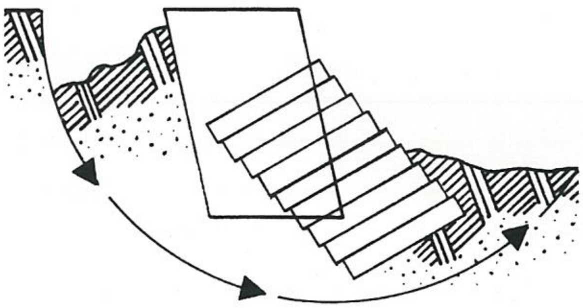
In cut situations, the exposed face is unstable because the soil holding it in place has been removed. Some of this weight needs to be replaced but in a much smaller area. In this circumstance it is often more economical to use TerraCell in lieu of other methods such as gabion baskets. When used in this manner, the stack of filled TerraCell panels acts as a near vertical, heavy, reinforced mass.

Design Considerations

A gravity retaining wall must have sufficient weight and width or be otherwise supported so that it does not overturn or slide forward due to external forces being exerted upon it. In addition, the wall must be able to hold together as a unit in order to function. That is, the wall must be stable with respect to both the external forces that might cause it to fall and the internal forces that might cause it to lose its shape and/or disintegrate.

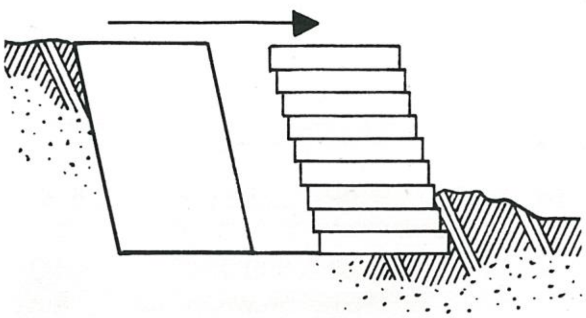
External Stability

TerraCell retaining walls must be designed to be stable with respect to four potential external failure modes: global stability, base sliding, overturning, and bearing capacity.



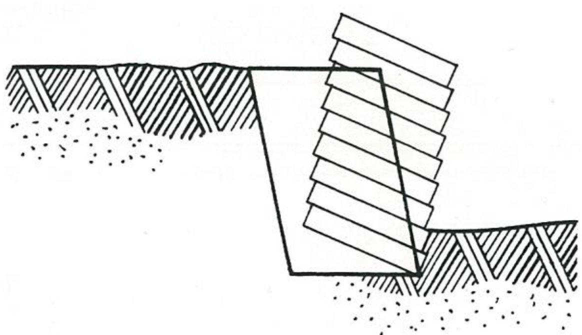
Global Stability

GLOBAL STABILITY refers to the stability of the wall, the soil behind it, and the soil below it. The design engineer must be certain that the entire area including the wall does not collapse. A thorough soil analysis must be performed to eliminate the possibility of global failure.



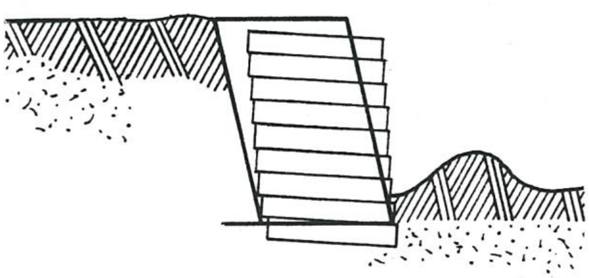
Base Sliding

BASE SLIDING refers to the outward movement of the bottom of the retaining wall as a result of the lateral forces generated by earth pressure and, if present, water pressure. The force resisting base sliding is the friction between the fill in the bottom layer of TerraCell and the foundation soil beneath the bottom layer. If calculations show that the resisting force is less than required, the designer may increase the front-to-back dimension of the wall, thereby increasing the area available to develop the resisting force. A second option would be to use a fill with greater frictional characteristics.



Overturning

OVERTURNING refers to the tipping over of the retaining wall as it rotates about the toe of the structure. The overturning force is the sum of each destabilizing force times its moment arm. The stabilizing force, or righting moment, is the product of the weight of the retaining wall and its moment arm, which is the horizontal distance from the toe to the center of gravity of the wall. If calculations show that the righting moment is less than required, one option is to increase the front-to-back dimension of the wall, thus increasing its overall weight and the magnitude of its moment arm.



Bearing Capacity

BEARING CAPACITY refers to the ability of the foundation soil to support the weight of the retaining wall placed upon it. The analysis is the same as for shallow foundations. If calculations show that the soil beneath the wall is too weak, it becomes necessary to increase the area of the base. This will decrease the pressure (force per unit of area) on the foundation. Another option is to increase the depth into the ground of the retaining wall, thus increasing the ability of the foundation soil to resist the imposed weight.

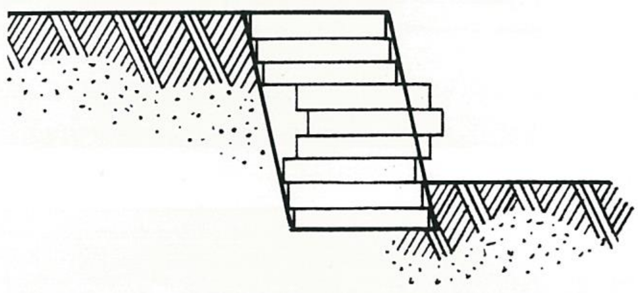
For each of these considerations, the resisting or stabilizing forces must exceed the forces that would cause failure by a predetermined factor of safety. The selected factors of safety should reflect the consequences of failure and the designer's confidence in the accuracy of the input parameters. The following factors of safety are normally used in the design of gravity retaining walls:

Global Stability:	FS_{gl}	=	1.3
Base Sliding:	FS_{sl}	=	1.5
Overturning:	FS_{ot}	=	2.0
Bearing Capacity:	FS_{bc}	=	2.0

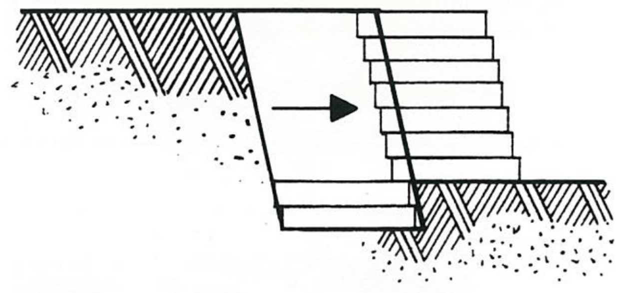
If the minimum front-to-back dimension of a wall that uses TerraCell is at least 0.6 times the wall height, the above factors of safety will be achieved in almost any design.

Internal Stability

Internal stability refers to the ability of the individual parts of the wall to act as a single unit. The wall must be designed so that the individual pieces of the wall do not pull out, separate, or slide apart. In a modular block wall, the designer must be concerned with the potential of the tieback failing under tension or pulling out from the soil or the facia. Also, a failure could occur if the facia bulges out. In the case of retaining walls consisting of TerraCell and soil, the only internal stability consideration is the potential for sliding between panels. If a factor of safety of 1.5 or greater is not achieved with the initial design, the sections need to be made longer to increase the surface area, or a fill material with higher frictional characteristics needs to be selected.



Bulging



Internal Sliding

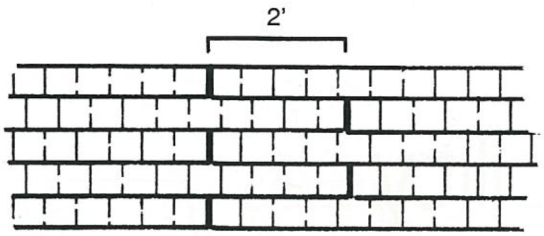
NOTE: For detailed design guidelines for retaining walls using TerraCell, please contact your local TerraCell distributor or WEBTEC, Inc.

The final design of any retaining wall must be developed by an engineer registered in the state where the project is located.

Installation

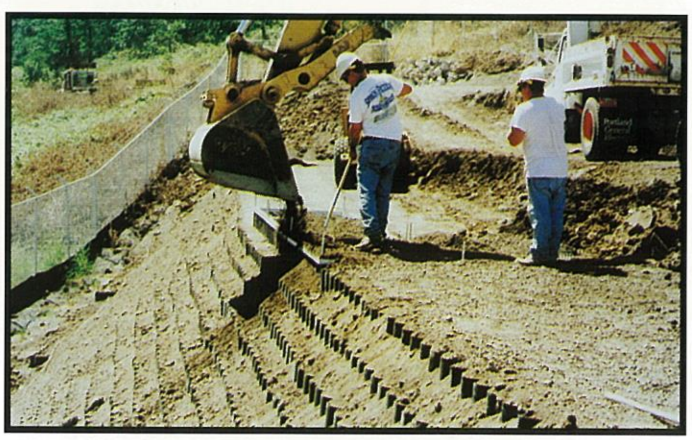
TerraCell is installed quickly and easily by a two- to four-man crew of semi-skilled labor without the use of any specialized equipment. In most retaining wall/steepened slope applications, the 8-inch Large Cell (19.2" x 16" cell size) is recommended. The expanded panels are 8 feet wide by the required length (up to 60 feet). Sections are shipped to the job site in collapsed form for ease of handling.

Each panel is stretched out to its full length and placed on the foundation or on top of the panels that are already in place. If the fill material is different from the foundation material, or from one panel to another, then it is recommended that a separation geotextile be placed between the foundation and the bottom panel or between the panels. The panels are held open by steel pins or a frame. Once a panel is filled, the frame is removed. The pins may be removed or left in place to hold the panels together or to anchor a geogrid to the panels.



Stacked Panels
(attached and offset by 2')

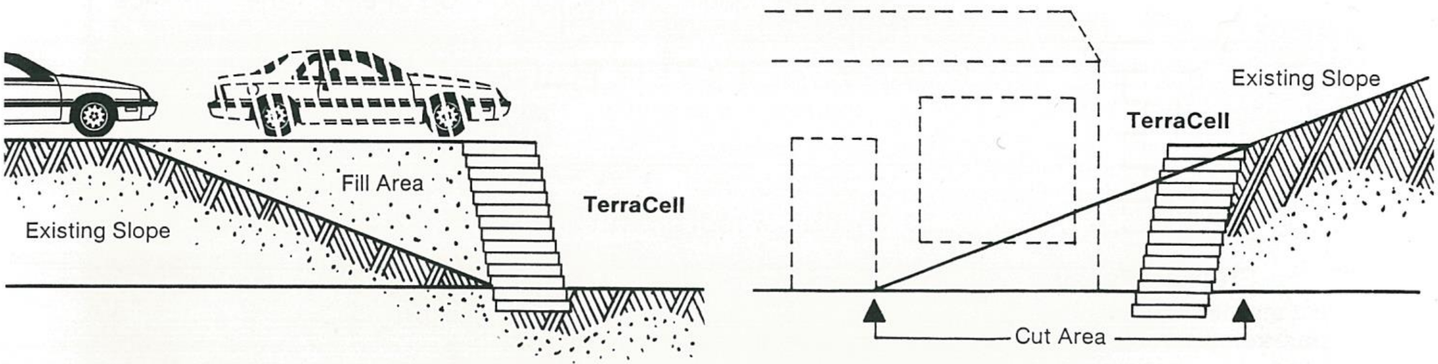
As the panels are stacked on top of each other, the face panels can be set back as much as the design requires. Sides of panels should be alternatingly offset at least 2 feet if the wall is more than one panel wide. Splicing of two or more panels is not allowed in the front-to-back direction. The cells can be filled with a variety of materials, including gravel for drainage or topsoil (at the facia) for root growth.



Economics

In many projects such as highway widening, rapid changes in grade are a necessity. In other projects such as apartment complexes on a steep slope, a rapid change in grade is the most efficient means of putting the available land area to economic use. A cost-effective way to achieve a rapid change in grade is to construct a reinforced earth gravity wall or slope.

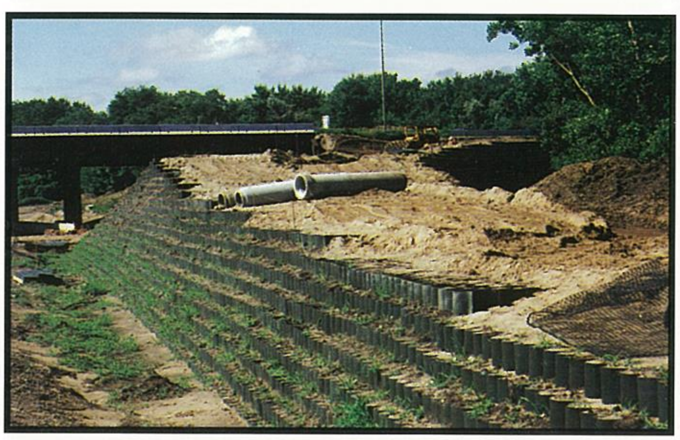
TerraCell, by itself or in combination with TerraGrid, can be as effective as more expensive alternatives such as cast-in-place, steel-reinforced concrete retaining walls, modular block walls, or gabion baskets. TerraCell is lightweight, easy to handle, can be filled with on-site materials, and does not require any special equipment for installation.

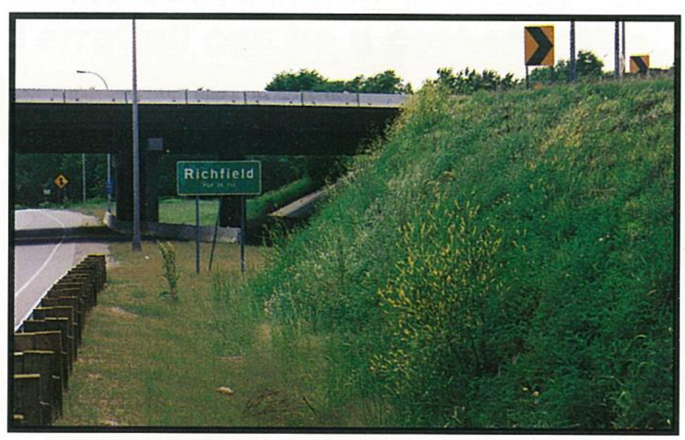


Filling And Cutting To Put Available Land Areas To Economical Use

Aesthetics

The outer cells of a TerraCell panel can be filled with topsoil and planted with grass, shrubs, or flowers. A vegetated TerraCell wall or steepened slope can give a look that blends in with the local surroundings, adds color to the area, and softens the appearance of the wall face. In addition, a vegetated wall will absorb much of the amount and force of any water that flows down the slope. This can have a significant impact on the potential consequences of a large quantity of water pouring down a steep wall face.





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