CELLULAR CONFINEMENT
1.0 MECHANICS OF RETAINING WALLS

The two basic types of retaining walls are cantilever and gravity. Most cantilever retaining walls are made of cast-in-place, steel-reinforced concrete and retain earth due to their internal strength and rigidity. However, reinforced concrete retaining walls are expensive to build, cannot be built in very cold weather, and are not especially attractive. They are also brittle and stress from differential settlement can cause cracks to develop, affecting stability and appearance.

Gravity retaining walls are constructed principally of soil that is stabilized with man-made materials such as EnviroGrid® and retain earth by virtue of their weight. Gravity retaining walls are typically inexpensive to build and can be built in nearly all weather conditions. In addition, they have a degree of flexibility and adjust to small amounts of differential settlement without suffering structural damage.

EnviroGrid® can also be used to create a steepened slope. Steepened slopes are constructed much steeper than the soil’s critical angle of repose. A steepened slope made with EnviroGrid® can be considered a retaining wall if the face inclination is greater than 70°.

2.0 DESIGNING WITH ENVIROGRID

An EnviroGrid® retaining wall or steepened slope can be constructed in almost any situation where a rapid change of grade is desired and can be used in both fill and cut applications.

In fill applications, a retaining wall consisting of an EnviroGrid® facing element and a geogrid reinforced soil zone is a cost-effective option. Unlike the more common modular block facing, EnviroGrid® is easy to handle, flexible, and can be planted for a natural look.

In cut situations, the exposed face is unstable because the soil mass holding it in place has been removed. Some of this weight needs to be replaced, but in a much smaller area. Gabions are one approach. However, a stack of filled EnviroGrid® panels acting as a near vertical, heavy, reinforced mass can be a more economical and attractive option.
A gravity retaining wall requires sufficient weight, width or mechanical support to resist external forces that may cause it to overturn or slide. It must also resist the internal forces that may cause it to lose its shape or become deformed.

2.1 EXTERNAL STABILITY

EnviroGrid® 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 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 is the outward movement of the bottom of the retaining wall due to lateral forces such as earth or water pressure. The force resisting base sliding is the friction between the fill in the bottom layer of EnviroGrid® and the foundation soil below. If calculations show that the resisting force is insufficient, the designer may increase the walls’ front-to-back dimension to create greater area to develop the resisting force. A second option would be to use a fill with greater frictional characteristics.

OVERTURNING is the tipping over of a retaining wall as it rotates about its toe. The overturning force is the sum of each destabilizing force times its moment arm. Moment arm is the horizontal distance from the toe to the walls’ center of gravity. The stabilizing force, or righting moment, is the product of the weight of the retaining wall and its moment arm. If calculations show that the righting moment is insufficient, one option is to increase the wall’s front-to-back dimension, increasing its overall weight and the magnitude of its moment arm.
BEARING CAPACITY refers to the foundation soils’ ability to support the weight of the retaining wall. If the soil is too weak, the footer area needs to be increased so the pressure is more evenly distributed on the foundation soils. Another option is to increase the depth of the footer.

For each of these, the resisting or stabilizing forces must exceed the forces of failure by a predetermined factor of safety. The factors of safety should reflect the consequences of failure and the designer’s confidence in the accuracy of the input parameters. The following are typical factors of safety used in gravity retaining wall design:

1) Global Stability (FSgl) = 1.3  
2) Base Sliding (FSsl) = 1.5  
3) Overturning (FSot) = 2.0  
4) Bearing Capacity (FSbc) = 2.0

If the minimum front-to-back dimension of a wall utilizing EnviroGrid® is at least 0.6 times the wall height, the above factors of safety will be achieved in most designs.

2.2 INTERNAL STABILITY

Internal stability is the ability of the individual parts of the wall to act as a single unit. To avoid failure, the individual pieces of the wall cannot pullout, separate, or slide apart. In a modular block wall, there is potential for the geogrid failing under tension or pulling out from the soil or fascia. The fascia (block) can also bulge out.

The only internal stability concern for walls consisting of EnviroGrid® and soil is possible sliding between panels. If a factor of safety of 1.5 or greater is not achieved in design, the sections need to be made longer to increase the surface area or the fill material needs to be changed to one with greater frictional characteristics.
NOTE: The final design of any retaining wall must be developed by an engineer registered in the state where the project is located.

3.0 ECONOMICS

The increasing scarcity of quality land for development requires innovative ways to use less desirable land. In 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. In projects such as highway widening, rapid changes in grade are a necessity. A cost effective way to achieve a rapid change in grade is to construct a reinforced earth gravity wall or slope.

EnviroGrid®, with or without geogrid reinforcement, can be as effective as more expensive alternatives such as cast-in-place, steel-reinforced concrete retaining walls, modular block walls, or gabion baskets. EnviroGrid® 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
4.0 AESTHETICS

EnviroGrid® can be filled with topsoil and planted with grass, shrubs, or flowers. The outer panel cells are available in non-perforated black, tan, or green. These options combine to offer a vegetated wall or steepened slope with a softer face that blends in with the local surroundings and adds color to the area.

In addition, a vegetated wall absorbs much of the volume and force of water flowing down it, mitigating the potential consequences of large quantities of water pouring down a steep wall face.

5.0 LEED® GREEN BUILDING CREDITS

Use of EnviroGrid® may make your project eligible for the following LEED® green building credits.

1) LEED® Sustainable Site Credit 5.1: Site Development—Protect or Restore Habitat
2) LEED® Sustainable Site Credit 5.2: Site Development—Maximize Open Space
3) LEED® Sustainable Site Credit 6.1 and 6.2: Storm Water Design—Quantity and Quality Control
4) LEED® Sustainable Site Credit 7.1: Heat Island Effect—Non-roof
5) LEED® Materials & Resources Credit 5.1 and 5.2: Regional Materials

Please refer to the US Green Building Council Website for further details on the LEED® certification system at www.usgbc.com.

6.0 INSTALLATION PROCEDURES

6.1 BEFORE STARTING

1) Ensure site conditions and EnviroGrid® layout are per construction drawings.
2) Ensure all specified materials and system components are delivered to the site.

6.2 SITE & SUBGRADE PREPARATION

1) Remove debris and vegetative cover from the installation area.
2) Complete initial earthwork according to plans.
3) Remove in-situ soils that are unacceptable for the EnviroGrid® wall foundation and replace with suitable materials.
4) Prepare the foundation soils as specified prior to base material placement.

6.3 INSTALLATION OF THE FOOTING

1) Expand the EnviroGrid® footing section into its designated position.
2) Hold the expanded section open using one of the following options:
   a. Straight stakes
   b. J-Hooks
   c. Envirobars
   d. Other options are also acceptable.
3) Overfill the EnviroGrid® footing section with the specified infill material and level to approximately 2 inches above the cell wall.

4) Place infill material around the EnviroGrid® footing section.
   a. Ensure this does not conflict with placement of the drainage system.
5) Compact fill and infill material to 95% of Standard Proctor Dry Density.

6.4 INSTALLATION OF THE DRAINAGE SYSTEM

1) Install specified sub-drain pipe at the location and elevation shown on the construction drawings ensuring that a minimum gradient of 2% is maintained to all outlets.
2) Ensure all pipe connections are properly made and that the sub-drain pipe is connected to outlet pipes or a subsurface drainage system.
3) Encapsulate the sub-drain pipe with drainage material (sand, pea gravel, clear stone, etc.) that is wrapped with a geotextile.
4) Wrap all outlet pipes passing through the wall face with a geotextile to prevent loss of the cell infill material.
5) Ensure discharge from outlet will not cause erosion that may affect wall stability.

6.5 EXCAVATION PROTECTION & DRAINAGE

1) Where specified, place a geotextile over the base and on the cut slope behind the EnviroGrid® wall.
2) Where specified, install the appropriate drainage composite materials. Ensure that the system is connected to a suitable outlet or sub-drain system.
6.6 INSTALLATION OF THE ENVIROGRID® SECTIONS

1) Expand the EnviroGrid® wall section into its designated position.
2) Hold the expanded section open using one of the following options.
   a. Straight stakes
   b. J-Hooks
   c. Envirobars
   d. Other options are also acceptable.
3) Check each EnviroGrid® wall section to ensure that it is fully expanded.
4) Correctly align and interleaf edges of adjoining EnviroGrid® wall sections and ensure that the upper surface of the adjoining sections are flush.
5) Fasten EnviroGrid® wall sections together with staples or as specified on the drawings.
6) Overfill the EnviroGrid® wall section with the specified infill material and level to approximately 2 inches above the cell wall.
7) Compact the infill material to 95% of SPDD.
8) Place specified backfill material behind the EnviroGrid® wall sections and compact to 95% of SPDD.
   a. In cut areas, extend the backfill back to the cut slope.
   b. In fill areas, place backfill as specified on the construction drawings.
9) Heavy compaction equipment can be used to compact backfill materials to within 3 feet of the EnviroGrid® wall sections. Use lighter walk-behind compaction equipment directly behind the wall sections.
10) After compaction of each layer, remove excess materials off the top of the EnviroGrid® section so that the top of the cellular structure is visible.

11) When positioning the next layer, ensure that:
   a. The proper setback of each layer is maintained.
   b. Proper side-to-side cell alignment is maintained to prevent loss of cell infill.

12) When installing freestanding or very steep EnviroGrid® wall structures, lay a 16 inch strip of non-woven geotextile over the outer row of cells in each layer to prevent loss of infill.

13) When special infill material (such as topsoil) is required in the exposed row of face cells, the following construction techniques may be employed:
   a. Cover the outer cells with movable boards to prevent the interior-cell infill material from spilling into the cells requiring special infill. After completing compaction remove the boards and fill the empty cells with the special infill.
   b. Each layer should be opened and infilled separately starting with the lowest layer and working to the upper layers.

6.7 INSTALLATION OF GEOSYNTHETIC REINFORCEMENT (when required by design)

1) Place precut sections of geosynthetic reinforcement between the EnviroGrid® layers according to the construction drawings. Insure the reinforcement layers are:
   a. Placed horizontally with the high-strength axis perpendicular to the wall face.
   b. Flat and free from folds.
   c. Placed so that the leading edge is within a minimum of 6 inches from the front of the wall and extends horizontally into the compacted backfill zone.
2) Place and infill the next EnviroGrid® wall section.
3) Manually tension the reinforcement by pulling it back from the filled EnviroGrid® sections.
4) Pin the back edge of the reinforcement layer so that it is taut and without folds.
5) Place backfill over the reinforcement in lifts of 10 inches starting from behind the EnviroGrid® wall sections and spreading the backfill towards the back of the reinforced zone.
   a. Only operate tracked equipment within the reinforced backfill zone after a minimum of 6 inches have been placed over each reinforcement layer.
   b. Rubber tired equipment can operate directly on the reinforcement using care to avoid sudden stops and sharp turns.
   c. Ensure that excessive displacement of the reinforcement does not occur during backfill placement.
6) Shape and compact the infill material to 95% SPDD.
7) Continue with this sequence until the EnviroGrid® retaining wall is complete.

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