Design Guidelines for Soil Stabilization

The EnviroGrid® Solution

Designing with EnviroGrid®

Installation
Design Guidelines for Soil Stabilization

When traffic loads are applied to a soil subgrade, the soil will not deform or rut if the shear strength of the soil exceeds the applied loads. The strength of the soil is a function of such characteristics as its angle of internal friction, its cohesion, and its degree of compaction.

Most road and parking systems consists of one or more layers of good quality fill materials placed and compacted on soil subgrades. The fill materials allow the system to support traffic loads that the soil, by itself, would not be able to withstand. The function of the layer(s) of base material is to distribute the imposed loads over a large area, thereby reducing the pressure (load divided by area), which is transferred to the subgrade. The base material is able to distribute the loads because the individual aggregate particles lock together. Applied loads are transmitted through the base material both as vertical and horizontal forces.

If the horizontal (lateral) forces push the base material sideways, rutting develops, resulting in a thinner layer less able to resist additional load applications which leads to failure. Even a good quality base material, with the proper internal strength and interlocking of individual particles, can be forced to move laterally. The poor quality subgrade in contact with the base material does not provide the required friction at the interface to restrain the movement.
The EnviroGrid® Solution

In order to prevent lateral movement at the bottom or within the base layer, high modulus (low elongation) geotextiles or geogrids have been used for many years. Because of their strength, resistance to elongation, and structure, fabrics and grids are more capable of restraining the lateral movement of the base materials with which they come in contact. Although they are very useful in many stabilization applications, fabrics and grids can only have an effect at the boundary where they contact the base material/soil. Prevention of lateral movement of the base materials above and below this boundary still depends totally upon the quality of the base material itself. EnviroGrid® takes the concept of confinement from two dimensions (length and width) and expands it to a third dimension (depth). This vertical and horizontal confinement of the entire depth of the base layer represents a quantum leap in stabilization technology, and has major implications upon cost effectiveness and the project’s long-term performance.

Because the cell walls resist lateral movement, a lower quality, lower cost, base material can be used. Additionally, the base material can be more open graded which will dramatically improve drainage of the system, resulting in a longer expected life for the road/parking lot. If a parking lot is not paved, storm water would be allowed to seep into the subgrade, possibly eliminating the need for a detention pond. Another major benefit of stabilizing soils with EnviroGrid® is the effectiveness of a geocell to distribute applied loads over a large area. Since each cell within a section is connected to adjoining cells, each section of EnviroGrid® acts as a large mat or pad. EnviroGrid® significantly reduces the pressure applied to the subgrade by a load exerted on the top surface of the EnviroGrid®. The benefit is that stabilization can be achieved with a minimum amount of base material used in conjunction with EnviroGrid®.
Designing with EnviroGrid®

EnviroGrid® filled with a base material acts as a layer in a multi-layer road system. A broadly accepted method used to analyze and design multi-layered road systems is a two-step procedure developed by AASHTO (American Association of Highway and Transportation Officials).

THE FIRST STEP
The engineer determines the necessary overall strength of the road system, which is called the required Structural Number (SN). The SN is a function of three (3) factors:

1. Soil Support Value (SSV)
The strength of the subgrade soil is determined by one of a variety of standard methods. Through the use of equivalence tables, the subgrade strength is used to select the appropriate Soil Support Value.

2. Equivalent Axle Load (EAL)
The expected traffic loads over the life of the system are tabulated. These include H2 loading (20-ton trucks with a given wheel configuration), lighter trucks, autos, etc. Using a table developed by AASHTO, each type of loading is converted to a common, single measure based on the impact, which that loading is expected to impose upon the road system. The common measure is a single 18,000 lb. Axle load and is called the Equivalent Axle Load.

3. Regional Factor (RF)
This factor accounts for the susceptibility of the subgrade soils at the construction site to conditions of moisture and temperature. The Regional Factor, which typically ranges from 0.5 to 3.0 in the forty-eight contiguous states, can be selected from a map developed for this purpose.

The engineer enters these three factors into a monograph developed by AASHTO that determines the required SN.
THE SECOND STEP

Select base materials and the thickness of the layers of those materials which, when combined, will provide an SN equal to or greater than the required SN. Each base material is assigned a Structural Coefficient (SC), which is related to the ability of the material to spread applied loads. It has been conservatively determined that the SC for EnviroGrid® filled with granular material such as sandy soil is 0.35. A better load-bearing fill material would increase the EnviroGrid® structural coefficient. In the following table are structural coefficients for various fill materials and EnviroGrid® filled with sandy soil, and the resulting equivalent layer thickness:

<table>
<thead>
<tr>
<th>EQUIVALENT LAYER THICKNESS*</th>
<th>ASPHALTIC CONCRETE</th>
<th>CRUSHED STONE</th>
<th>SANDY GRAVEL</th>
<th>LIME STABILIZED SOIL</th>
<th>SANDY SOIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>4” EnviroGrid® (10 cm)</td>
<td>3.4 inches (8.6 cm)</td>
<td>10 inches (25 cm)</td>
<td>12.7 inches (32 cm)</td>
<td>17.5 inches (45 cm)</td>
<td>20 inches (51 cm)</td>
</tr>
<tr>
<td>(SC = 0.35)</td>
<td></td>
<td></td>
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<tr>
<td>6” EnviroGrid® (15 cm)</td>
<td>5.1 inches (13 cm)</td>
<td>15 inches (38 cm)</td>
<td>19.1 inches (49 cm)</td>
<td>26.3 inches (67 cm)</td>
<td>30 inches (76 cm)</td>
</tr>
<tr>
<td>(SC = 0.35)</td>
<td></td>
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</tr>
<tr>
<td>8” EnviroGrid® (20 cm)</td>
<td>6.8 inches (17 cm)</td>
<td>20 inches (51 cm)</td>
<td>25.5 inches (65 cm)</td>
<td>35 inches (89 cm)</td>
<td>40 inches (102 cm)</td>
</tr>
<tr>
<td>(SC = 0.35)</td>
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</tbody>
</table>

* Filled with Sandy Soil

Multiplying the SC of a given material by the thickness of the layer of that material, in inches, determines the contribution of that layer toward the required SN. For example, if the required SN is 2.90 and the engineer wants the top layer of the road system to be 2” of asphalt concrete, he or she could make either of the following selections for the remainder of the base:

1. 15” of crushed stone \( (15 \times .14) + (2 \times .41) = 2.92 \)
2. 6” EnviroGrid with sandy soil \( (6 \times .35) + (2 \times .41) = 2.92 \)
Alternatively, if the engineer knows how much of a base material is normally used in a given design, he or she can substitute EnviroGrid® for that material in relation to their structural coefficients. For example, EnviroGrid® filled with sandy soil has five times (.35/.07=5) the support value of sandy soil without EnviroGrid. Thus, 4” EnviroGrid® filled with sandy soil has the same load bearing strength as 20” of sandy soil without EnviroGrid®. Therefore, if a road design calls for 18” of a sandy soil fill, the engineer could reduce that amount to 4” EnviroGrid® with the same type fill and have a stronger base.

The designer can add local fill materials to the above table with the appropriate AASHTO structural coefficients to calculate the savings using EnviroGrid®. Examples of such locally available materials are crushed shell in coastal areas, river gravel in mountainous areas, coal slag from mining projects and high quality limestone in other areas.

A complete description of the AASHTO design procedure, as well as its development and complete software for use in design, is available from AASHTO at (202)624-5800 or at www.aashto.org.
Environmental Merit

The EnviroGrid® geocell is designed and implemented in order to maximize environmental benefit. Geo Products recognizes that construction generally leaves a significant footprint upon the environment, and therefore seeks to reduce any impact that our EnviroGrid® incurs upon the landscape. The limited amount of infill required for EnviroGrid® as opposed to conventional construction methods, as well as the lower quality needed, offers not only a much softened blow to the environment but also reduces project engineering, length, and cost. In addition to a significantly lower construction and carbon footprint upon the environment, EnviroGrid® acts as a green building practice in diminishing erosion along slopes and embankments. The vegetative cover encouraged by EnviroGrid® is another source of soil stabilization as well as aesthetic value more difficult to achieve with conventional construction.

As an innovative method to facilitate green thinking, EnviroGrid® is an effective solution to protect and preserve the environment when such a mindset is growing ever more desirable.

LEED® Green Building Credits

The Leadership in Energy and Environmental Design (LEED®) system for designing and certifying environmentally sustainable buildings is the national standard for rating environmentally responsible construction. Introduced and enabled by the United States Green Building Council, LEED® takes into account materials and resources used, site location and development, air quality, and water and energy use in its evaluation of green buildings.

Geo Products' EnviroGrid cellular confinement system is designed and implemented with environmental merit as a top priority, and contributes heavily to a higher LEED® rating for your green building project. Please refer to the US Green Building Council Website for further details on the LEED® certification system at www.usgbc.com.
**LEED® Sustainable Site Credit 5.1: Site Development--Protect or Restore Habitat**

Requirements:
For Greenfield sites--sites not previously developed and remain in a natural state--limit all site disturbance to the specified parameters. For previously developed areas, restore or protect a specified area of the site with acceptable vegetation.

*Geo Products Solution and LEED® Credit Opportunities:*
EnviroGrid provides options for pervious paving in parking and access road functions, thus reducing disruption to existing ecosystems and minimizing the construction footprint. Also, through the stabilization of steepened slopes and of storm water detention facilities, EnviroGrid is able to reduce the construction footprint and keep site disturbance within the necessary parameters.
For previously developed building areas, use of the EnviroGrid geocell allows for the restoration or promotion of vegetation, thus contributing to the ecosystem and further minimizing site disturbance.
The retaining wall and slope stabilization features of EnviroGrid reduce valuable land consumption in an environmentally-friendly fashion.

**LEED® Sustainable Site Credit 5.2: Site Development--Maximize Open Space**

Requirements:
To provide acceptable, vegetated open space within the project boundary in accordance with specified parameters, and to reduce development footprint.

*Geo Products Solution and LEED® Credit Opportunities:*
EnviroGrid is ideal for encouraging useful vegetated open space whether with green parking areas through load support functions or by reducing land consumption with environmentally friendly slope stabilization and earth retention purposes. In any application, EnviroGrid is designed to provide the most open space by eliminating the need for further drainage facilities or by allowing for steeper slopes with minimized environmental damage.

Please visit our website [http://www.geoproducts.org/EnvironmentalMerit.aspx](http://www.geoproducts.org/EnvironmentalMerit.aspx) for additional information on the sustainability and environmental merit of EnviroGrid including LEED® Green Building Credits and more.
Installation

A four to six man crew of semi-skilled labor without any specialized equipment installs EnviroGrid® quickly and easily. Sections are shipped to the jobsite in collapsed form, measuring 12’ x 5” x cell height (3.65 m x 127 mm x cell height).

1. If required, excavate and shape the subgrade soil to the elevations, grades, and dimensions as shown on the project drawings.

2. If the infill material is different from the sub-base material, a geotextile should be used as a separator. A woven or nonwoven fabric is selected depending on whether strength or permeability is important. Simply unroll the geotextile directly on the subgrade, overlapping adjacent panels by 12” (30 cm) (minimum).

3. Place a straight stake or J-hook stake in the middle of the first row of cells of the unexpanded panel. Recommended stake length is 3X the cell wall height. If the plans call for removing stakes after filling, pound stakes in to a depth allowing 4”-5” above the cell
wall to allow for easy removal. Measure a distance matching the expanded panel length and place a stake where the middle of the last row of cells will be when expanded. Pull the panel to this stake and place over stake. Expand the width of the panel to the designed panel width and place a stake in all 4 corners. Additional stakes may be needed along the perimeter in order to get full expansion of each cell. In situations where it is not practical to use stakes (over rocky soil, geomembrane liners, etc.) an installation frame may be used. Another option is to place sandbags in the cells on the outside perimeter until nearby cells are filled. Adjacent sections are installed in a similar fashion and stapled together to achieve continuous coverage.

4. Fill the first rows of cells with a front-end loader or dump truck and push the fill into cells using shovels or a bulldozer blade. A “ramp” of fill material immediately adjacent to the EnviroGrid® will likely be necessary to allow equipment to climb onto the EnviroGrid®. Continue until all cells are filled. Never allow any equipment to drive over unfilled cells. Always overfill the cells slightly to allow for compaction.

5. Next, it is necessary to compact the EnviroGrid® system. The most common method of compacting is through multiple passes by the tracked equipment used to spread the infill. A vibrating roller and/or water may be required to achieve the specified level of compaction.

6. Once the cells are filled and the system is compacted, the EnviroGrid® base is ready to withstand heavy traffic loads.