TERRACELL®

CELLULAR CONFINEMENT SYSTEM

DESIGN GUIDELINES FOR GROUND STABILIZATION

The TerraCell® Cellular Confinement System is a three-dimensional, "honeycomb" structure made from strips of polyethylene. It is designed to reinforce or stabilize poor load-bearing soils.

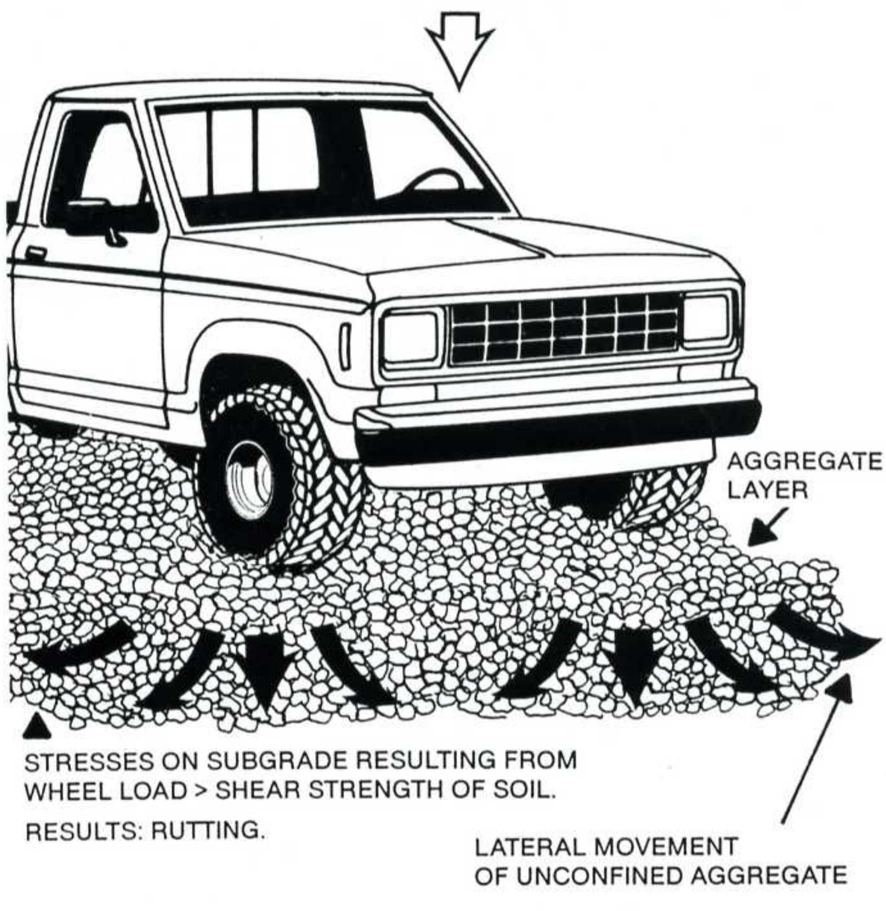
Streets • Roads • Highways
Parking Lots • Storage Areas • Construction Entrances
Fire and Emergency Vehicle Access Lanes
Runways • Taxiways • Aprons/Overrun Areas
Railroad Track Beds • Temporary Access Roads /Logging Roads
Stream Crossings • Boat Ramps • Water /Sewer Lines

Mechanics of Ground 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.

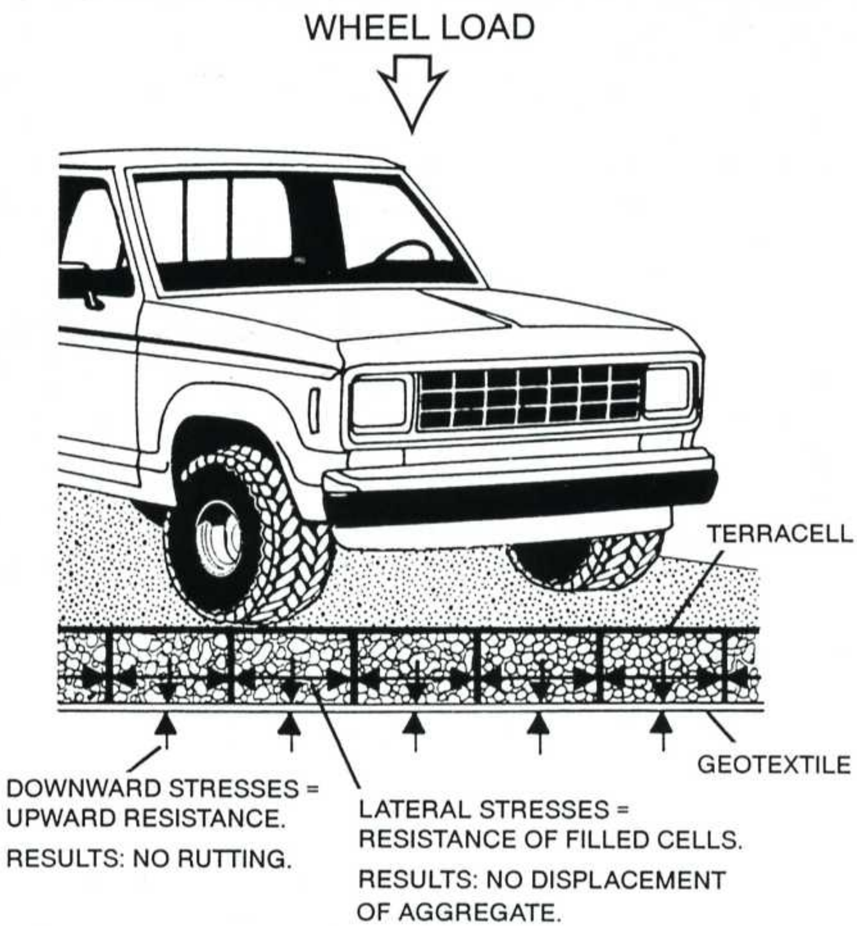
Most road and parking systems consist of one or more layers of good quality fill materials placed and compacted on soil subgrades. The fill materials allow the system to support traffic loads that the soil, by itself, would not be able to withstand. The function of the layer(s) of base material is to distribute the imposed loads over a larger 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 **TerraCell** Solution

In order to prevent lateral movement at the bottom or within the base layer, high modulus (low elongation) geotextiles such as TerraTex® GS or geogrids such as TerraGrid® 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. TerraCell 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 materials 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 the 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 TerraCell 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 TerraCell acts as a large mat or pad. TerraCell significantly reduces the pressure applied to the subgrade by a load exerted on the top surface of the geocell. The benefit is that stabilization can be achieved with a minimum amount of base material used in conjunction with TerraCell.

Designing with **TerraCell**

TerraCell 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).

In 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:

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.

EQUIVALENT AXLE LOAD (EAL)

The expected traffic loads over the life of the system are tabulated. These include H20 loadings (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. This common measure is a single 18,000 lb. axle load and is called the Equivalent Axle Load.

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 nomograph developed by AASHTO which 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 that material to spread applied loads. It has been conservatively determined that the SC for TerraCell filled with a granular material such as sandy soil is 0.35. A better load-bearing fill material would increase the TerraCell structural coefficient. In the following table are structural coefficients for various fill materials and TerraCell filled with sandy soil, and the resulting equivalent layer thickness:

EQUIVALENT LAYER THICKNESS	ASPHALTIC CONCRETE SC = .41	CRUSHED STONE SC = .14	SANDY GRAVEL SC = .11	LIME STABILIZED SOIL SC = .08	SANDY SOIL SC = .07
4" TerraCell filled with Sandy Soil (SC = .35) is equivalent to	**3.4 inches**	**10 inches**	**12.7 inches**	**17.5 inches**	**20 inches**
6" Terra Cell filled with Sandy Soil (SC = .35) is equivalent to	**5.1 inches**	**15 inches**	**19.1 inches**	**26.3 inches**	**30 inches**
8" TerraCell filled with Sandy Soil (SC = .35) is equivalent to	**6.8 inches**	**20 inches**	**25.5 inches**	**35 inches**	**40 inches**

SC = Structural Coefficient

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:

a. 15" of crushed stone **(15 x .14) + (2 x .41) = 2.92**

b. 6" TerraCell with sandy soil **(6 x .35) + (2 x .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 TerraCell for that material in relation to their structural coefficients. For example, TerraCell filled with sandy soil has five times (.35/.07 = 5) the support value of sandy soil without TerraCell. (In his book entitled ***Designing with Geosynthetics***, Fourth Edition, Prof. Robert Koerner provides an example which shows that the use of an 8" geocell increases the bearing capacity of sandy soil by **13** times.) Thus, 4" TerraCell filled with sandy soil has the same load bearing strength as 20" of sandy soil without TerraCell. Therefore, if a road design calls for 18" of a sandy soil fill, the engineer could reduce that amount to 4" TerraCell 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 TerraCell. Examples of such locally available materials are crushed shell in coastal areas, river gravel in mountainous areas, and high quality limestone in other areas.

Installation

TerraCell is installed quickly and easily by a two to four man crew of semi-skilled labor without any specialized equipment. Sections are shipped to the job site in collapsed form, measuring 11' x 5" x cell height.

1. If required, excavate and shape the subgrade soil to the elevations, grades, and dimensions as shown on the 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 18" (minimum).

3. Determine where the first section of TerraCell is to be placed and put stakes at the four corners (typically an 8' x 20' area).
4. Stretch a section beyond its intended length and then allow it to relax. Place the section over the embedded stakes. 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, etc.), an installation frame may be needed. Adjacent sections are installed in a similar fashion and butted or stapled together to achieve continuous coverage.

5. 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 TerraCell will likely be necessary to allow equipment to climb onto the geocell. Continue until all cells are filled. ***Never allow any equipment to drive over unfilled cells.*** Always overfill the cells slightly to allow for consolidation.
6. Next, it is necessary to compact the TerraCell 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.

7. Once the cells are filled and the system is compacted, the TerraCell base is ready to withstand heavy traffic loads.

Anchoring Methods

In most stabilization applications, where the ground is fairly level, TerraCell sections are held open during in-filling with rebar or wooden stakes.

Sometimes it may be more economical or necessary to open the TerraCell sections with an installation frame. The frame can be constructed from common lumber (or PVC) and rebar.

Economics

Dealing with unstable soils can be very expensive with costs ranging from construction downtime to extensive excavation to the importing of costly fill materials. The use of TerraCell to stabilize weak soils can:

1. Minimize or eliminate excavation needed to create enough depth to allow sufficient fill to be placed to support anticipated loads and still maintain specified grade level.

2. Reduce the amount of fill material needed to spread loads such that forces acting on the subgrade do not exceed the strength of the subgrade.

3. Allow the use of less expensive, lower quality fill materials without sacrificing the load distributing capabilities of the system. In many cases, local fill materials can be used in place of expensive materials trucked in from off-site.

4. Create a free draining base material which, if left unpaved, would allow storm water to seep into the subgrade and not alter the percolation rate of the site, thereby possibly eliminating the need for a detention pond.

TerraCell can be used in almost any ground stabilization application. Not only can it reduce fill costs, it also improves the quality of the finished product (roads, parking lots, etc.). Use of TerraCell can eliminate the need to constantly add aggregate to a site or repair paved surfaces that have failed due to an unstable subgrade.

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