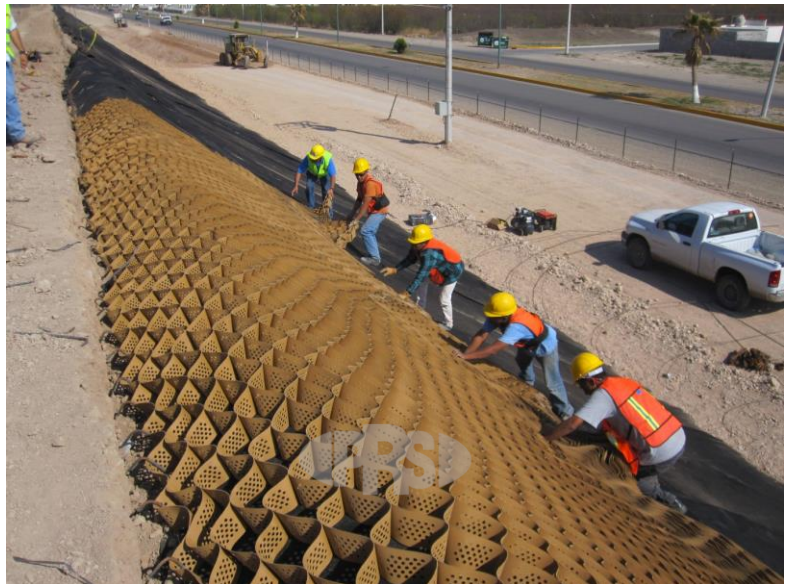


Neoloy® Geocell Slope Protection



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Version 2018 Revision 1

TECHNICAL OVERVIEW

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INTRODUCTION

The Neoloy Geocell cellular confinement system is a soil confinement, stabilization and reinforcement solution comprised of 3D, perforated and textured honeycombed geocells that protect soil from surface erosion, unstable slopes and hydraulic forces.

Neoloy can be applied to a wide range of soil stabilization and reinforcement applications subject to surface erosion and unstable slopes, including slope, levee and channel protection, earth stabilization, and geomembrane protection for reservoirs and landfills. Vegetation is typically used as a surface cover, while hard-armor is used for slopes with more severe erosional pressures.

The high long-term tensile reinforcement of the soil, enhanced drainage, and cell-soil-plant interaction of Neoloy provides downslope stability against sliding and erosional effects and from hydrodynamic and gravitational forces.

STABILIZE SOILS AND SLOPES

Effective slope and soil reinforcement is provided by:

- Frictional resistance which reduces sliding
- 3D confinement, which enhances soil particle structure and soil integrity, minimizing the impact of rain and floods
- Cell perforations facilitating plant and root interlock, thereby stabilizing the soil mass and enabling free drainage

An anchoring system with or without tendons is used to fasten the geocell system to the native soil and prevent sliding downslope.

Their density is determined by subgrade, weight and type of infill, slope grade and environmental conditions.

By protecting soil and slope integrity Neoloy prevents runoff erosion, sedimentation to local water bodies and loss of fines (air-borne dust) to preserve the natural environment. Neoloy is a more cost-effective, green natural vegetative cover and maintenance-free alternative to erosion control blankets, turf reinforcement mats, gabions and rip-rap solutions.

Neoloy slope protection is also applicable to **Channel Protection**. Neoloy with vegetated soil or hard armor surface cover infill optimizes erosion protection for natural or man-made channels and hydraulic structures.

Neoloy is differentiated from other geocells by the Neoloy® novel polymeric alloy, which guarantees reliable performance over the project lifespan.





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SURFACE COVERS

Neoloy's confinement efficiency reduces the quantities of whichever surface cover is used making it cost-effective.

Vegetative Cover – Landscaped Slopes

The Neoloy cellular confinement is a mechanical erosion barrier that preserves the soil structure, while minimizing the impact of raindrops and surface runoff. The Neoloy cell walls and perforations provide an excellent growth stratum for roots and plants. These enhance the growth of planted vegetation and facilitate plant and soil interlock to stabilize the soil mass even further.

Hard Armor Granular Slope Cover – for Shorelines, Landfills, Berms

Channel applications subject to surface erosion, unstable slopes and hydraulic forces – as well as geomembranes – can be protected with Neoloy using gravel or crushed stone infill. Neoloy provides effective protection for the following:

- Slopes/channels subject to severe erosional and hydraulic forces from water, wind or ice
- Landfill, waste treatment where the critical objective is to protect the geomembrane
- Shoreline, bank protection, berm protection of chemical tanks without concrete

Hard Armor Concrete Slope Cover – For Drainage Trenches & Channels

Concrete infill is used in places with high flow rates and hydraulic stress, for example, in drainage ditches and trenches at the bottom of highway slopes / embankments subject to concentrated storm water run-off. As the Neoloy honeycombed cells function as the forms for pouring, forms as well as reinforcements, setting or curing times are eliminated. Concrete can be poured in one stage, making it easier, faster and more uniform. Savings in concrete and project timetables can be significant. The resulting structure functions as a flexible slab that accommodates minor subgrade movement and prevents cracking.





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BENEFITS

Design & Construction

- **Geocells** – physically protect against run-off, rill and gully formation and erosive forces
- **Frictional resistance** – reduces soil sliding & migration
- **Cell perforations** – facilitate plant, root and soil interlock to further stabilize soil mass and slope

Material

- **Unique Neoloy® polymer technology** – very high resistance to UV, oxidation, water, extreme temperatures

Operational

- **Soil confinement** – enhance soil structure and minimizes impact of raindrops
- **Drainage** – promote infiltration and limit the impact of hydrostatic forces

Economic

- **Cost effective** – reduces the quantities of surface cover required (topsoil, gravel or concrete)
- **Long lifespan** – maximizes project lifecycle costs



Environmental

- **Sustainable** - enables flow of water, nutrients and soil organisms
- **Landscape value** – enhance plant growth, soil health and visual landscape

DURABILITY

Neoloy is comprised of advanced polymeric alloys that make the cellular confinement system stiff, flexible and durable. In particular the Neoloy patent-pending alloys feature long term dimensional stability, high long term design strength (creep resistance) and low reduction factors. This translates to a longer life-span for Neoloy earth retention structures. In addition, Neoloy is non-degradable and is resistant to weathering, extreme temperatures and water, which can affect concrete, steel and timber solutions.

SUSTAINABLE SOLUTION

Neoloy is the best-available sustainable solution for long-term soil protection and stabilization in slopes, embankments and retaining walls. Neoloy Geocells improve site ecology by enhancing water drainage and soil quality, and when integrated with revegetation schemes, improve the site landscape, soil food web and visual aesthetics.

The **Neoloy perforations** promote infiltration and limit the impact of hydrostatic forces by improving drainage. This plays a crucial role in soil protection by:



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- Preventing run-off and soil erosion
- Preserving the soil structure
- Enabling flow of water, nutrients and soil organisms

Healthy soil encourages the growth of vital soil organisms and processes that improve nutrient cycling, porosity and soil aggregation. The perforations are also critical in promoting revegetation by providing an excellent growth environment for roots and plants. This further stabilizes the soil and slope, while facilitating the restoration of the vegetation and landscape.

STORMWATER MANAGEMENT

Neoloy Geocells are suitable for new water management techniques for the localized control of stormwater. Neoloy cellular confinement preserves the soil structure, tolerates high sheet-flow conditions and is self-draining for high infiltration.

Neoloy is also ideal for soil protection of contoured open-channel drainage ditches and bioswales used to manage stormwater runoff. It prevents soil erosion and channeling, while providing an excellent growth medium for the growth of turf and vegetation. This assists the on-site infiltration to reduce runoff, filter pollutants, prevent flooding and augment underground water resources.

NEOLOY SLOPE PROTECTION SOLUTIONS

- **Transportation and Construction**
 - Cut & fill slopes
 - Road and rail embankments
 - Abutment protection
- **Energy**
 - Protective berms for Petrochemicals
 - Pipeline stabilization
- **Stormwater Management**
 - Drainage trenches
 - Bioswales
- **Environmental**
 - Green roofs
 - Mine and quarry restoration
- **Reservoirs**
 - Ponds, lagoons, dams
 - Channel and shoreline structures
- **Landfill**
 - Waste containment facilities
 - Waste rehabilitation sites





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BASIC GUIDELINES FOR SLOPE PROTECTION

Selecting the Neoloy Geocell category, size and height is dependent upon a number of planning parameters. These include the slope inclination, the functional use, the environment and hydraulic stress, and the infill type and availability. Category A and B PRS-Neoloy Geocells are typically used for most moderate to steep slope inclinations and moderate to high flow velocities. The size (length / width) and height of the geocell are used to optimize the solution for the specific project parameters and costs.

SURFACE COVER OPTIONS

Vegetative	Gravel	Concrete
		
Topsoil combined with planted vegetation. Soils with fines require more protection – a smaller cell size and higher cell height. If subject to intense rainfall/runoff, more granular infill soil should be used.	Permeable Aggregate. If a permeable surface is necessary (and not a green landscape) or to reduce the overall cost, (local) granular infill can be used. The greater resistance of granular material to erosion enables use of a larger cell size and lower cell height.	Hard armor concrete Concrete is used on slopes subject to high flow velocities, such as in drainage trenches, channels and reservoirs. The size and height of the Neoloy Geocell is based on the flow velocities.

TOPSOIL AND VEGETATED SURFACES

A key benefit of Neoloy is the ability to use local native (top) soil for infill. Whereas local soil infill is the most sustainable and economic solution, this serves as a starting point for planning. Although soil with fines is the most suitable infill for landscape vegetation, granular infill provides better erosion and slope protection. In general a mix of fines and granular (stone) soil provides the best solution. As the quality of the infill increases (more granular) the less protection (confinement) is needed. In terms of selecting the Neoloy cell size:

- More protection (confinement) – requires a smaller cell size and higher cell height
- Less protection – can utilize larger cell size and lower cell height

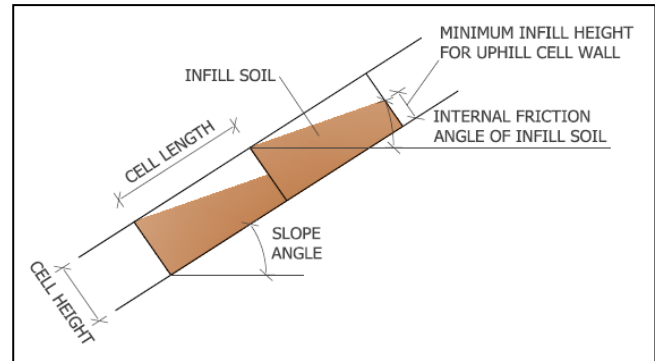
An alternative to providing more confinement in the face of higher erosive forces is to use higher quality infill comprised of more granular material.



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INTERNAL FRICTION ANGLE

The main factor in planning is the type of infill to be used, which is calculated by its **internal friction angle**. Based on planning nomograms available from PRS, the cell size and height can be selected in order to achieve sufficient /minimum infill of the cell on the **uphill wall** of each cell.



The suggested Neoloy solution is based on the **minimum requirements** – that means the largest cell size and lowest cell height.

If the site is subject to significant rainfall and/or runoff (or thin vegetative cover), it is recommended to choose a higher level of Neoloy protection, meaning a smaller cell size and/or higher cell.

Infill	Typical Internal Friction Angle
Topsoil	20 °
Topsoil & granular material	28 °
Granular	36 °

Neoloy is an excellent stratum for revegetation providing a microclimate for seed germination and mechanical protection of young plants. However, there is a minimum thickness layer of the topsoil required to establish healthy vegetative cover. Therefore for revegetation schemes it is recommended to define first the cell height and then define the size of cell (length and width).

It should be noted that as the landscape cover becomes more established over time, the vegetation provides significantly improved infill soil stability and better erosion control. The perforations in the cell walls enable interlocking root growth, which further stabilize the slope and soil mass.

PRS

PRS is the world's leading supplier of cost-effective earth stabilization solutions. Combining unique proprietary technology with specialized engineering expertise, PRS delivers proven solutions for load support, slope and channel protection, earth retention, and reservoir and landfill applications. With a global network of regional offices and local distributors, PRS provides a full range of end-to-end support services. Since its establishment in 1996, PRS has implemented thousands of successful projects in over 45 countries worldwide.





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CHOOSING THE NEOLOY CATEGORY

The following table explains how to select the Neoloy Geocell that matches the actual needs of the project, pre-calculated by typical stresses, loading, photochemical durability, elevated temperatures and design-life and not just the cell dimension. Different cell sizes and heights are available according to design objectives.

The PRS approach departs from the commonly accepted practice of using standard strength (HDPE) geocells (of different sizes and heights) for all project types, and takes into account the project design requirements, thereby avoiding over- or under-design.

Tables of Neoloy Categories (A-D)

NEOLOY CATEGORIES – GENERAL			
A	B	C	D
Suitable for low to moderate slopes and flow velocities	Suitable for moderate to high slopes and flow velocities	Suitable for very steep slopes & very high flow velocities	Suitable for the most demanding slope and channel solutions

NEOLOY VS. SLOPE TYPE CATEGORIES – DETAILED SUITABILITY					
PROJECT CATEGORIES		NEOLOY GEOCELL CATEGORIES			
		A	B	C	D
SLOPES ⁽¹⁾	<i>Max. Slope</i>	<i>Max. Height (m)</i>	<i>Max. Height (m)</i>	<i>Max. Height (m)</i>	<i>Max. Height (m)</i>
	34°	unlimited	unlimited	unlimited	unlimited
	45°	10	12	15	20
	63°	3	4	5	6

* NOTES:

(1) SLOPES

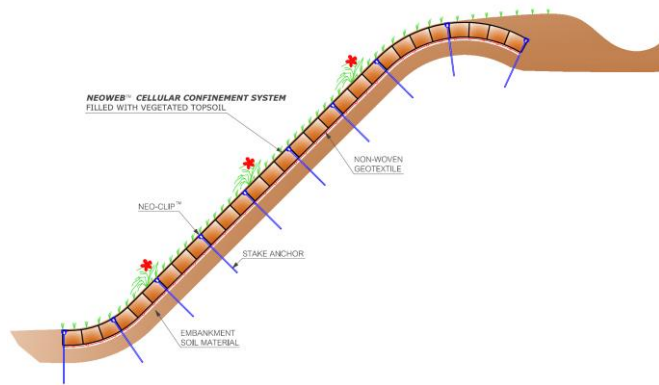
- Cell height and size are according to design requirements, determined mainly by slope inclination
- Topsoil infill, vegetated slopes
- Typical stake anchor: embedded depth=500 mm, diameter=10 mm
- Parameters are without tendons, which can be added for higher performance/heights.
- Stake anchor density [units/m²]: $\alpha \leq 34^\circ$: 1.0-1.2 | $34^\circ < \alpha \leq 45^\circ$: 1.2-1.5 | $45^\circ < \alpha \leq 63^\circ$: 1.5-1.8:
Higher stake densities enable higher slopes for each category
- Non-woven geotextile under-layer (optional)



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VEGETATED SLOPE PROTECTION (1)

Neoloy Slope Cover Protection System, Expanded Downslope



PARAMETER	DESCRIPTION
STABILITY	Stable slope at natural state for desired inclination and height
INCLINATIONS	1:3 - 1:1 (18° - 45°)
HEIGHT	No limitation
SOLUTION	- Erosion control system - Green solution - Protects slope strength properties for long term stability
FEATURES	- Easily installed on any changing/curved geometry - Enables efficient confined drainage system
INFILL	Vegetated / locally excavated soil infill
ANCHORAGE	Metal / wood stakes + clip

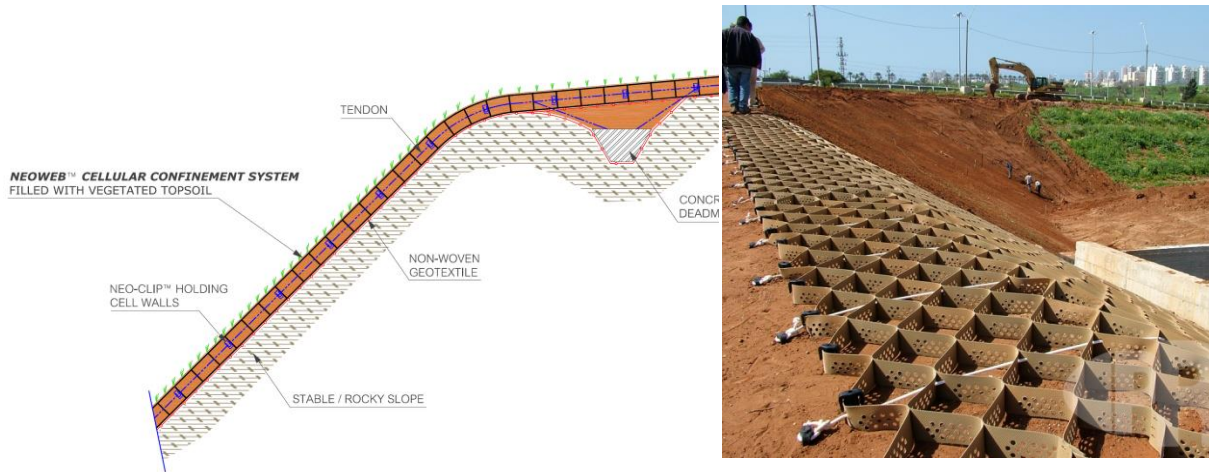
NOTE: THE ILLUSTRATIONS IN THIS DOCUMENT ARE EXAMPLES ONLY AND NOT INTENDED FOR PLANNING, CONSTRUCTION, BIDDING, OR PERMIT PURPOSES.



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VEGETATED SLOPE PROTECTION (2)

Neoloy Slope Cover Protection System, Expanded Downslope with Tendons



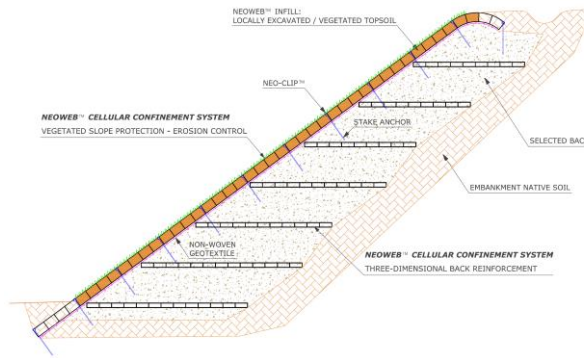
PARAMETER	DESCRIPTION
STABILITY	Stable slope at natural state for desired inclination and height
INCLINATIONS	1:3 - 2:1 (18° - 63°)
HEIGHT	Depends upon inclination, up to 15-25m
SOLUTION	- Erosion control system - Green solution - Protects slope strength properties for long term stability
FEATURES	- Easily installed on any changing/curved geometry - Enables efficient confined drainage system
INFILL	Vegetated / locally excavated soil infill
ANCHORAGE	- Tendons + clip holding cell walls - Tendons secured to deadman anchors at crest



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REINFORCED SLOPE & EROSION CONTROL

Neoloy Stabilized Reinforced Slope and Slope Cover Protection System



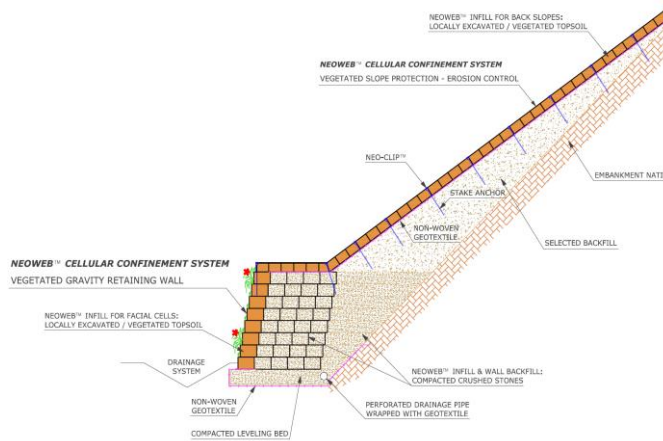
PARAMETER	DESCRIPTION
STABILITY	- Unstable slope at natural state for desired inclination and height - Slope requires earth retention structure to provide stability
INCLINATIONS	1:2 – 2:1 (27° - 63°)
HEIGHT	Typical range: 2.0 - 12.0m
SOLUTION	- Earth retention system - Erosion control system - Green solution - Unique reinforcement of three-dimensional Neoloy system
FEATURES	- Flexible structure: retains its resistance after dynamic/seismic actions, without cracking - Easily installed with curves at any longitudinal geometry - Enables efficient confined drainage system - Simultaneous construction of Neoloy structure and embankment
INFILL	- Vegetated / locally excavated soil infill for exposed slope - Granular soil for reinforced backfill and Neoloy reinforcement
ANCHORAGE	Metal / wood stakes + clip for slope protection system



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EARTH RETENTION & STABILIZED EROSION CONTROL

Combined Neoloy Gravity Retaining Wall and Back Slope Cover Protection System



PARAMETER	DESCRIPTION
STABILITY	- Unstable slope at natural state for desired inclination and height - Slope requires earth retention structure to provide stability
INCLINATIONS	- Wall: 1:1 - 6:1 (45° - 81°) - Slope: 1:3 - 2:1 (18° - 63°)
HEIGHT	- Typical range for gravity wall: 0.6 - 4.0m - Typical range for reinforced wall: 3.0 - 12.0m - Slope: no limitation
SOLUTION	- Earth retention system - Erosion control system - Green solution - Protects slope strength properties for long term stability
FEATURES	- Flexible structure: retains its resistance after dynamic/seismic actions, does not crack - The wall and slope can be easily installed with curves at any longitudinal geometry - Enables efficient confined drainage system
INFILL	Vegetated / locally excavated soil infill in first fascia cells and in back slope protection
ANCHORAGE	Back slope anchorage system: metal stakes + clip



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APPENDIX 1 - INSTALLATION

Installation Tasks

- Safety first & steps before starting
- Site preparation
- Layout sections
- Fasten sections
- Anchor stakes
- Expand sections
- Special situations
- Infill

Safety First

- Site preparation - check for underground utilities
 - Traffic control and signs - for safety
- Personal Protective Equipment
 - Helmets, vests, gloves
- Power Tools
 - Operate according to manufacturer instructions
- Construction vehicles
 - Adhere to standard procedures
- Fill operations and paving layers
 - Be aware of hazards
 - Follow standard procedures

Key Points to Remember

- Before starting
 - Verify specified materials and work tools onsite
 - Have construction drawings in hand
- Layout
 - Ensure proper direction & cell opening
- Infill Operations
 - Prevent damage to cells by equipment

Tools & Equipment

- Neoloy Geocell Sections (palletized)
- Anchors and clips (optional)
- Pneumatic Stapler & 1/2" (13 mm) galvanized staples
- Compressor and Generator
- Geotextile (if specified)
- Optional standard hand and power tools

Material Storage & Handling

- Prevent damage during:
 - Transport
 - Storage

- Handling
- If in extended storage, protect from:
 - Sun
 - Temperature
 - Equipment

Site Preparation

- Prepare channel and slope subgrade
 - Clear and grub
 - Complete earthwork grade, slope and elevations
 - Mark and stake
- Prepare crest shoulder or trench at top of slope
- Geotextile
 - Install according to manufacturer instructions
 - Ensure overlap

Layout Sections on Site

- Layout
 - Disperse sections parallel to slope crest
 - Orientation of sections is critical to system performance and shall be verified by contractor or engineer
 - Save cut sections for reuse

Fasten Sections with Pneumatic Stapler

- End to End
 - Align & interleaf ends of 2 sections
 - Fasten seams of each strip
 - Do not skip strips (or cells)
- Repeat the process to fasten sections (panels) face to face according to the downslope length

Staple Properly

- Always staple seams
- Do not skip cells (face to face) or strips (end to end)
- Use the correct no. of staples per cell height
 - < 75 mm – 3 staples
 - <100 mm – 4 staples
 - <150 mm – 5 staples
 - <200 mm – 6 staples



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Anchor Stakes along Shoulder / Crest

- Geotextiles
 - Permeable – through fabric
 - Non-permeable – on side of fabric
- Anchor at fixed intervals
 - According to cell size and construction drawings
 - Mark with string to align

Expand Neoloy Sections Downslope

- Expand sections
 - Place over anchors on one side / top of crest
 - Open and expand to other side / downslope
- Verify
 - Cells are opened to correct dimensions
 - Cut extra cells

Special Situations

- Curves
 - Over-expand outer cells
 - Under expand inner cells
 - May not exceed 15% nominal cell dimensions
- Use trapezoidal section for wide curves

Placing Infill

- Do not operate vehicles on cells
- Placing Infill – soil, gravel or concrete
 - Infill top rows first
 - Limit drop height to 1m
 - Overfill cells >2 cm above cells
 - Compact soil infill with shovel blade or smooth concrete with level board
 - Remove large debris from soil
 - No cells exposed





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