Geosynthetics for soil reinforcement
Reinforced soil engineering

For millennia, civilizations have sought effective methods to construct stable soil retaining structures. The technique of reinforced soil is not a new concept. Many ancient structures incorporated layers of natural tensile elements to reinforce the soil for construction of stable structures.

In a modern context, reinforced soil has become a viable and cost-effective technique only over the last 30 years. This was brought about by the development of geosynthetic reinforcements engineered from strong and durable polymers. These geosynthetic reinforcements enable substantial tensile loads to be supported at defined deformations over extended design lives.

Mechanics of reinforced soil

Reinforced soil is the technique where tensile elements are placed in the soil to improve stability and control deformation. To be effective, the reinforcements must intersect potential failure surfaces in the soil mass. Strains in the soil mass generate strains in the reinforcements, which in turn, generate tensile loads in the reinforcements. These tensile loads act to restrict soil movements and thus impart additional shear strength. This results in the composite soil/reinforcement system having significantly greater shear strength than the soil mass alone.

Benefits of reinforced soil

Reinforced soil is a very cost-effective technique compared to other construction techniques. The major benefits of reinforced soil are:

• The inclusion of reinforcement in soil improves the shear resistance of the soil thereby improving its structural capability.
• The inclusion of reinforcement enables the use of poorer quality soils to be used as structural components.
• Land acquisition can be kept to a minimum because reinforced structures can be made steeper than would otherwise be possible.
• Construction time can be reduced when reinforced soil techniques are used.
**Mirafi® geosynthetics for reinforced soil**

**Strength:** Mirafi® geosynthetic reinforcements are manufactured in a wide range of strengths. This is to ensure that all reinforced soil applications can be covered in the most efficient manner.

**Durability:** Mirafi® geosynthetic reinforcements are manufactured from highly durable polymers that can maintain strength, stiffness, and soil interaction over extended design lives. Typical design lives may range from 1 to 2 years for a temporary reinforced soil structure, to 120+ years for a permanent reinforced soil structure.

**Interaction:** Mirafi® geosynthetic reinforcements are manufactured to maximize the interaction efficiency between the geosynthetic reinforcement and the surrounding soil. Interaction is important because it is the mechanism by which stresses and strains are transferred between the geosynthetic reinforcements and the surrounding soil.

**Mirafi®’s advantages**

Mirafi® geosynthetic reinforcements have a number of advantages for reinforced soil applications:
- They have been engineered specifically for soil reinforcement applications.
- They are manufactured from strong and durable polymers.
- They are factory produced to specific quality standards. Thus, they do not have the inherent variability of naturally occurring materials.
- They are light in weight. Thus, they are easy to transport to construction sites and easy to handle during placement.
Factory fabrication is an effective way of minimizing field operations. Mirafi® fabricated geosynthetic products lead to faster, easier and more accurate installation, plus significant cost savings.

Mirafi® offers complete factory fabrication capabilities including seaming of extra wide panels, production of composite products, re-rolling of fabric onto special pipes or cores, and geosynthetic folding to facilitate field installation.

**Geolon® HS-Series**
- Features & Benefits:
  - Higher tensile strength than any comparable product
  - Excellent creep resistance
  - Excellent soil confinement, resulting in greater load distribution

**Geolon® HP-Series**
- Features & Benefits:
  - Higher tensile strength at 2-5% than any comparable product
  - Uniform openings providing flow characteristics as that of a fine coarse sand layer
  - Excellent soil confinement

**Miragrid® XT-Series**
- Features & Benefits:
  - No recoiling
  - Flexible and tough
  - Lightweight
  - Cost effective
  - High LTDS
  - Easy Handling & Wide Rolls

**BasXgrid®**
- Features & Benefits:
  - True biaxial strengths
  - High tensile strengths at low strains
  - Excellent durability and performance
  - Cost effective
  - Easy handling & wide rolls
  - Reinforcement for most soil types

**CUSTOM FACTORY FABRICATION**

ONSITE SUPPORT

Our regional engineers and technical representatives are available to provide experienced onsite consultation for geosynthetic installation and field seaming. Mirafi® has the answers to any questions concerning geosynthetic placement and installation techniques.

**RESEARCH AND TESTING**

Extensive product performance and application testing spanning nearly a decade ensure that Mirafi® soil reinforcement products conform to the highest quality standards. Extensive independent testing has been conducted to determine the tensile strength, creep behavior, soil interaction characteristics, installation damage resistance, and long-term durability in various soil and chemical environments.
**CHALLENGE**
Provide stabilization and reinforcement of embankments constructed on soft foundation soils with low shear strengths and excessive consolidation settlements.

**SOLUTIONS**
Geolon® HP-Series and HS-Series can be placed directly on soft foundation soils to facilitate embankment construction and provide long term stability to the embankment. These high strength, high modulus geosynthetics offset the low shear strength of the foundation soils and maintain separation of the subgrade and select fill.

**ADVANTAGES**
- Facilitates construction of a working platform.
- Allows construction of higher embankments and steeper embankment side slopes.
- Promotes uniform settlement
- Minimizes construction time, required space and select fill costs.
- Eliminates excavation and replacement costs.
- Provides short and long term global stability to the embankment.

**Applications:**
- Highway Embankments
- Airport Runway Embankments
- Containment Dikes
- Flood Control/Hurricane Protection Levees
- Earth Dams
- Berms
Applications:

- Highway Embankments
- Earth Dams
- Residential Developments
- Mining/Mine Reclamations
- Commercial/Office Parks
- Landfills
- Dikes/Levees
- Stream Channelization
- Berms

CHALLENGE
Construct a steep reinforced embankment or slope within limited property line boundaries.

SOLUTIONS
To steepen soil slopes, Miragrid XT-Series are placed in layers during construction to intercept and stabilize potential failure planes. Miragrid XT-Series soil reinforcement impart tensile strengths to the soil, thereby increasing the slopes overall factor of safety against sliding or rotation.

ADVANTAGES
- Allows for construction on limited right-of-way sites.
- Minimizes land acquisition costs.
- Maximizes useable space.
- Eliminates the need for higher cost retaining walls
- Lowers site development costs.
- Speeds development and construction of a site.
- Provides aesthetically pleasing vegetated surfaces.
CHALLENGE
Provide low cost, engineered soil tensile reinforcement solutions for a variety of retaining wall applications.

SOLUTIONS
State-of-the art Miragrid XT® technology allows for the construction of reinforced soil retaining walls at significant savings of time and cost. Mirafi® geosynthetics’ low material and installation costs typically save 25 to 50 percent compared with conventional cast-in-place concrete retaining walls.

ADVANTAGES
• On-site fill can be used.
• Low material and installation costs.
• Large differential settlements can be accommodated.
• Allow for a variety of facing options including treated timbers, concrete SRW units, wrap around and vegetated facings, gabions, pre-cast concrete panels, wire baskets, natural stone, and driven sheet pile to provide superior aesthetics versus conventional cast-in-place concrete retaining walls.

Applications:
• Segmental Retaining Walls (Concrete SRW Units)
• Head Walls/Bridge Abutments
• Crusher/Quarry/Batch Plant Abutments
• Stream Channelization
• Solid Waste Transfer Stations
• Blast/Sound Walls
• Coastal Protection/Sea Walls
subgrade stabilization

**Applications:**

- Unpaved Temporary Haul Roads
- Paved Roads over Weak Subgrades
- Foundation Support
- Parking Lots
- Commercial & Industrial Access Roads

**CHALLENGE**

Improve the load bearing capacity of weak subgrades consisting of soft clays, silts and organic soils.

**SOLUTIONS**

*Geolon® HP-Series* geosynthetics allow construction over weak subgrades by uniformly distributing the load, improving bearing capacity, and providing tensile reinforcement to weak subgrade. By minimizing the required aggregate base course thickness, and providing a stable working platform, *Geolon® HP-Series* geotextiles offer a lower cost method of construction as compared to subgrade displacement, excavation and replacement, and chemical stabilization.

**ADVANTAGES**

- Lower the initial cost of construction by reducing the required aggregate by 30 to 50 percent.
- Increase the design life and reduce maintenance costs by maintaining aggregate thickness, and structural and drainage capacity of the base course over the life of the structure.
- Prevent localized overstressing of the subgrade thus reducing pavement deterioration.
- Eliminate costly delays by allowing all-weather construction.
- Facilitates initial fill placement and compaction on weak subgrades.
- Enables equipment access to job sites.

![Diagram of subgrade stabilization](image)
challenge
Increase the passive bearing capacity of granular base course material.

solutions
BasXgrid® biaxial geogrids provide high tensile strength at low strains increasing the passive bearing capacity of base course materials when placed as a tensile element either at the subgrade/base interface or within the base course layer. The grid structure provides optimum interaction in all types of soil. By stabilizing the base and distributing the loads over a greater area, BasXgrid® geogrids greatly enhance the engineering properties of the aggregate base course.

advantages
• Can provide lower initial cost of construction by reducing the required aggregate base course by up to 40%
• Increase the design life and reduce maintenance costs by maintaining thickness, structural capacity, and drainage capacity of the base course throughout the life of the system.
• Facilitates initial compaction and aggregate placement over soft subgrades
• Provides exceptional stress transfer at low strain, allowing the reinforcing characteristics of the geogrid to be developed.
• Aperture stability provides optimum interaction between the geogrid soil.

applications:
• Base reinforcement for paved roads
• Construction haul roads
• Permanent unpaved roads
• Working platforms for weak subgrades
• Parking lots
• Foundation support
• Commercial and industrial access roads
• Secondary reinforcement for soil retaining structures
Applications:

- Municipal Solid Waste Landfills
- Roads and Highways over Areas Subject to Void Development
- Control of Subsidence over Pipes and Other Subsurface Structures
- Karst Topographic Areas/Polygonal Ground
- Mining/Mine Reclamations
- Control of Subsidence over Waste Trenches

CHALLENGE
Prevent failure of roads, foundations, flexible membrane liners and other earthen structures due to loss of subgrade support caused by subsurface voids. Geolon® HS-Series or Miragrid® XT-Series, acting as a “tensioned membrane”, spans the void and helps to prevent or minimize the effect of subgrade failure.

SOLUTIONS
Install single or multiple layers of Geolon® HS-Series or Miragrid® XT-Series over areas subject to circular or longitudinal voids. Geolon® HS-Series or Miragrid® XT-Series provides tensile strength to the soil and transfers overlying normal soil or waste loads away from the void area, thereby preventing excessive differential settlement.

ADVANTAGES
- Increases allowable waste height in MSW landfills.
- Installs easily during construction of the facility.
- Increases useable space.
- Eliminates the need for excavation and replacement.
- Lowers site development costs.
- Speeds construction of a facility.
- Supports sensitive liners.

Miscellaneous Landfill Use
Mirafi Geotextile Reinforcement to span voids
Liner system
Very irregular limestone surface with very weak ravel & voids
void void
natural grade
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Municipal Solid Waste Landfills
Roads and Highways over Areas Subject to Void Development
Control of Subsidence over Pipes and Other Subsurface Structures
Karst Topographic Areas/Polygonal Ground
Mining/Mine Reclamations
Control of Subsidence over Waste Trenches

voids bridging
Applications:
- Superfund Sites
- Hazardous Waste Cells
- Industrial Waste Lagoons (i.e., paper mills, chemical plants)
- Mine Tailings Ponds
- Dredge Spoil Containment Sites
- Sludge Pond Caps

CHALLENGES
Provide a safe, cost effective method of capping and stabilizing sludge ponds, cells and lagoons.

SOLUTIONS
Facilitate the site closure by employing Geolon® HP-Series or HS-Series to stabilize the soft cell contents and create a working platform for select fill placement. Geolon® HP-Series and HS-Series provide high tensile strengths at low elongations and high cross direction seam strengths to support fill placement over very low shear strength materials, as well as durability to survive severe installation stresses.

ADVANTAGES
- Minimizes construction time and cost by eliminating the need for excavation or chemical stabilization of the weak cell contents.
- Allows the removal of surface water by filtering or retaining the fine sludge particles of the low shear strength material.
- Provides critical separation between subgrade and select fill.
- High seam strengths (up to 70 kN/m (4800 lbs/ft)) allow faster deployment of the geotextile and facilitates safe placement of select fill.

Uniform tension is maintained by first filling in parallel ridges and then filling in between Stabilizing berms.

Sludge

Mirafi geosynthetic reinforcement panels with high strength seams

Original pond perimeters

Stabilizing berms

VIEW FROM ABOVE

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additional resources available for soil reinforcement applications:

**Technical Documents**
- Durability of High-Strength Geosynthetics
- Determination of the Long Term Properties for Miragrid® Reinforcement Geogrids
- Seaming of Geotextiles
- Filtration and Drainage
- Facing Options for Steepened Slopes

**Case Studies**
- Sludge Lagoon - Mirafi® FW402 & HP1500
- Embankment on Weak Soil - Mirafi® HS1500
- Reinforced Slope - Miragrid® 5XT
- Reinforced Steep Slope - Miragrid® XT
- Basal Reinforced Embankment - Mirafi® HP570
- Wrapped Faced Wall - Mirafi® HP370
- Basket Faced Wall - HS-Series and Miragrid®
- Segmental Retaining Walls - Miragrid®, N-Series

**Design Tools**
- Miraslope® Software
- Miraspec® Specification Generator and Product Selector

**Installation Guides**
- Reinforced Soil Slopes
- Reinforced Segmental Retaining Walls
- Veneer Reinforcement
- Soil Reinforcement
- Drainage Composites
- Liner Reinforcement
- Earth Retention with Cellular Confinement
- Channel Protection with Cellular Confinement
- Slope Protection with Cellular Confinement

**Application Brochures**
- Guidelines for the Selection of Woven Geotextiles for Subgrade Stabilization
- Guidelines for the Design and Specification of Reinforced Soil Retaining Structures