GEOFIBERS
Fiber Reinforcement for Soil

- Repair of Failed Slopes
- Reinforcement for Embankment and Levee Construction
- Reinforcement of Pavement Subgrade
- Reinforcement of Chemically Stabilized Pavement Layers

Fiber Soils
Fibers for Soil and Turf Reinforcement
Geosynthetic Fibers for
3-D Soil Reinforcement in
Roadway and Slope Applications
Using Traditional Equipment and
Construction Procedures
**General**

GEOFIBERS® fibers are typically 1-inch long discrete fibrillated polypropylene strands that are mixed or blended into soil. During this blending process, the fibrillated fibers open or filamentize into net, grid and fiber configurations that mechanically reinforce soils. This technology creates a new soil structure with enhanced engineering properties.

GEOFIBERS composite soils exhibit greatly improved performance properties. Stress-strain curves from unconfined compression tests show the addition of fibers increase the strain energy and residual bearing capacity when compared to unreinforced or chemically treated soil systems. For this reason, soils reinforced with GEOFIBERS carry an increased number of traffic passes to failure. GEOFIBERS reinforcement therefore improves the life of chemically treated sands or clays used in pavement layers.

Triaxial and direct shear tests show a 20 to 50 percent increase in the shear strength of cohesive soils reinforced with GEOFIBERS. Therefore, fiber-reinforced soils used in slope construction or slope repair exhibit higher factors of safety against failure than unreinforced soils. This feature allows for easy repair of failed slopes, construction of steeper slopes, and more efficient use of available land.

Depending upon actual soil characteristics and desired performance levels, a design dosage rate of GEOFIBERS is mixed into soil using standard construction methods. The fiber-reinforced soil is also placed and compacted using standard procedures and equipment. Chemical stabilizers (such as hydrated lime or portland cement) may also be used in conjunction with GEOFIBERS soil reinforcement when circumstances necessitate. The end result is an isotropic, reinforced soil with enhanced engineering properties and performance characteristics.

GEOFIBERS soil reinforcement fibers are made from polypropylene, a chemically stable and inert polymer. When mixed into the soil, these fibers do not pose any occupational safety concerns nor are they toxic to plant, animal or human life. Furthermore, GEOFIBERS have the distinct advantage of being reprocessed with the soil without effect to performance.
Mixing GEOFIBERS® into cohesive soils for slope repair and new slope construction increases the shear strength of the material. This benefit may allow steeper slopes to be constructed without the high costs associated with conventional retaining wall construction. Because of its simple application method, GEOFIBERS® reinforcement is ideal for use in slope repair projects. Many highway slopes are constructed at potentially unstable angles with little soils information due to time and budget limitations. Over time, the slope may lose stability and cause localized failure. Slope failures are unsafe, expensive maintenance problems that can be repaired by mixing GEOFIBERS® with fill soils prior to replacement.

Utilizing GEOFIBERS® soil reinforcement in a slope repair or new slope construction project is easily accomplished using standard construction techniques. Soils to be used in the slope construction are spread to a lift thickness which can be effectively mixed and meet compaction requirements. GEOFIBERS® are placed on the soil lift at a dosage rate calculated to the soil’s dry unit weight. The soil is then blended with GEOFIBERS® reinforcement using a rotary-pulverizer mixer. The soil is then replaced and compacted in lifts to build the intended slope geometry.

Localized surficial slumping and larger slope failures are ideal for the application of GEOFIBERS® reinforcement.

The soils to be used in the slope are spread in lifts and GEOFIBERS® are added.

The failed slope materials are blended with GEOFIBERS® at the design dosage rate, replaced and compacted to the original slope geometry.
Direct shear and triaxial compression test results using the design dosage rate of GEOfibers® soil reinforcement can be input to commercially available global slope stability programs. STABOM and UTEXAS2 are examples of programs that are able to carry out both geosynthetic-reinforced and GEOfibers fiber-reinforced slope stability analyses using personal computer hardware. Furthermore, internal slope stability analyses are not necessary (as with planar geosynthetics) since GEOfibers reinforcement is a homogenized portion of the soil composite.

Most agencies and engineers faced with the challenge of protecting land from floodwaters consider using locally available, low cost soils to build levees or embankments. Generally, bank slopes are built flat because of poor construction materials, but real estate costs in urban areas force the designer to look for other alternatives.

GEOfibers reinforcement can be mixed into these weak soils to provide internal reinforcement which may allow steeper slopes to be constructed. Furthermore, GEOfibers fiber-reinforced soils maintain higher shear strength during the periods of rapid drawdown commonly associated with saturated levees and embankments.

Levees and Embankments

Because GEOfibers® reinforcement results in the increased shear strengths of cohesive soils, lab test data can be input into commercially available global slope stability programs.

Levees, drainage channels, and other slopes associated with inland waterways can be constructed using GEOfibers® reinforcement.

GEOfibers® help to provide a solution for slope failures in flood channels utilizing on-site clay soils.
Soft subgrade soils, unacceptable subbase and base materials, and tight construction budgets are factors that favor the use of in-situ stabilization techniques in roadway construction. Rather than reducing the stresses applied to pavement layers with the inclusion of a planar geo-synthetic (such as a geotextile or geogrid), GEOFIBERS® blended into these materials homogenize and improve the performance characteristics of the soil itself. GEOFIBERS® reinforcement helps stabilize subgrade, subbase, and base courses or can be used in conjunction with chemical stabilization to create a strong, yet flexible reinforced soil composite.

Blending GEOFIBERS into an existing or new roadway structural layer is easily accomplished using standard construction techniques. The fibers are placed on the soil layer at a calculated dosage rate, evenly spread over the lift, and mixed into the soil with a commercial size rotary pulverizer mixer. The fiber-reinforced soil is placed and compacted using standard procedures and equipment. When circumstances necessitate, chemical stabilizers (such as hydrated lime or portland cement) may be used in conjunction with GEOFIBERS® reinforcement to further increase roadway performance.
The compacted pavement layer is usually fine-graded with a motor grader and “proof-rolled” with an acceptable roller. Standard paving techniques then proceed or additional base layers may be constructed in a similar manner.

The inclusion of GEOfIBERS® reinforcement provides additional life to roadways. Various projects and full scale field tests have been constructed throughout North America. These have demonstrated that the inclusion of GEOfIBERS provides increased pavement performance and durability.

GEOfIBERS soil reinforcement has been successfully installed in a wide variety of soils in subgrades and pavement layers. The strength and durability of sands, silts and clays can be reinforced through the addition of GEOfIBERS. Successful applications even include expansive clays with high plasticity indexes.
Synthetic Industries has invested in thoroughly researching and quantifying the improvements of GEOFIBERS® reinforcement makes to soils. Laboratory tests, field tests, and actual installation success have shown that mixing GEOFIBERS with untreated subbase and base courses, or chemically stabilized sand and clay soils, improves the life of those materials in pavement layers. These improvements have been demonstrated through unconfined compression, triaxial, and flexural beam tests in the laboratory, increased number of passes to failure in field tests, and through projects and applications constructed in North America.

In 1991, the US ARMY Corps of Engineers, Waterways Experiment Station (WES) and Synthetic Industries entered into a Cooperative Research and Development Program (CRDP). This was part of the Construction Productivity Advancement Research Program (CPAR). CPAR is designed to assist in the advancement of technologies that will have a direct positive impact on construction productivity and project costs. The primary purpose of this research was to investigate the structural benefits of the inclusion of GEOFIBERS in chemically stabilized soil layers used in pavement structures.

The layout of the test road provided for the evaluation and comparison of GEOFIBERS® reinforcement with several soil configurations.
The soils used in this study were a silty sand (SM) and heavy clay (CH). These soils were blended with the appropriate design percentages of chemical stabilizers (hydrated lime or Portland cement) and GEOFIBERS® reinforcement. An oval test track containing different thicknesses of each material was constructed. A complete field soils investigation was conducted prior to trafficking, during trafficking, and after failure of the various sections. Laboratory testing was conducted on the various test section materials to correlate laboratory value to actual field performance. Rut depth data was collected periodically during trafficking to monitor the performance of each item and document failure.\textsuperscript{1}

The data obtained from this field study clearly demonstrates the improved performance of untreated and chemically stabilized soil layers using GEOFIBERS® soil reinforcement in pavement structures.\textsuperscript{1}

Reference


The 12-inch fiber-reinforced silty sand section (FIBERS) provided a 33% increase in the number of traffic passes versus the similar unreinforced section (CONTROL).

The 6-inch fiber-reinforced clay section with hydrated lime (FIBERS) provided a 47% increase in the number of traffic passes versus the 6-inch crushed limestone section.
Properly prepared samples tested in unconfined compression (ASTM D2166) have shown the benefits of using *GEOFIBERS*® reinforcement in pavement sections. The inclusion of *GEOFIBERS* into brittle chemically stabilized soils exhibits enhanced bearing capacity at strains that exceed the elastic limit of the unreinforced material. This characteristic, known as strain-hardening, increases the strain energy in fiber-reinforced soils. Flexural beam testing has also shown this same effect in chemically stabilized soils reinforced with *GEOFIBERS*. This test also shows that the extent and severity of cracking is reduced by the addition of *GEOFIBERS* reinforcement. This results in reflective crack reduction in overlying pavement layers, which is a major problem in chemically stabilized roadways.

Laboratory tests show that *GEOFIBERS* reinforcement improves the shear strength and cohesion of soils to be used in slope construction. Direct shear tests (ASTM D3080) and consolidated, undrained triaxial compression tests (ASTM D4767) have quantified these improvements prior to design and application. Further analysis verified the repeatability of direct shear testing in cohesive soils reinforced with *GEOFIBERS*. Because of the homogeneous nature of the fiber-reinforced soil, the lab test results can be used to accurately predict shear strengths expected in the field.

These actual test results verify that cohesive soils reinforced with *GEOFIBERS* exhibit up to a 50% increase in the shear strength.
Prior to installation, a laboratory analysis is performed to determine the dosage rate of GEOFIBERS® required for the design performance level. This is commonly done by properly preparing and evaluating a series of test specimens with multiple addition rates. Dosage rates are typically determined to be between 0.1 to 0.3 percent of the soil’s dry unit weight. Please contact Synthetic Industries for a data base of test results or a laboratory guide.

The material shall be discrete, fibrillated polypropylene fibers that are mixed or blended into the soil. The fibers shall open or filamentize into net, grid and fiber configurations that mechanically reinforce the soil. This technology shall create a new soil structure with enhanced engineering properties. The fibers shall be resistant to ultraviolet degradation and to biological and chemical environments normally found in soils. The fibers are sealed in polyethylene bags and placed in cardboard cartons. These cartons are clearly labeled and shipped on pallets by the truckload. Synthetic Industries GEOFIBERS soil reinforcement conforms to the property values listed below:

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TEST METHOD</th>
<th>TYPICAL VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polypropylene</td>
<td>ASTM D4101</td>
<td>99.4 %</td>
</tr>
<tr>
<td></td>
<td>Group 1/Class 1/Grade 2</td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td></td>
<td>Black</td>
</tr>
<tr>
<td>Moisture Absorption</td>
<td></td>
<td>Nil</td>
</tr>
<tr>
<td>Fiber Length</td>
<td>Measured</td>
<td></td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>ASTM D792</td>
<td>0.91 gr/cm³</td>
</tr>
<tr>
<td>Carbon Black Content</td>
<td>ASTM D1603</td>
<td>0.6 %</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>ASTM D2256</td>
<td>45,000 psi</td>
</tr>
<tr>
<td>Tensile Elongation</td>
<td>ASTM D2256</td>
<td>15 %</td>
</tr>
<tr>
<td>Young’s Modulus</td>
<td>ASTM D2101</td>
<td>700,000 psi</td>
</tr>
</tbody>
</table>

Data listed above is subject to change without notice.
Our GEOFIBERS® soil reinforcement product specialists provide a wide variety of assistance for engineers, contractors, installers and distributors. Although GEOFIBERS are installed using traditional construction techniques, additional support is available from Synthetic Industries.

**Technical Support**

**ASSISTANCE INCLUDES:**
- Construction specifications
- Installation procedures
- On-site construction assistance
- Design approaches
- Laboratory soil testing and mixing procedures

---

**Fiber Soils**

FIBERS FOR SOIL AND TURF REINFORCEMENT

---

**JIMMY HILL**  
Office 225-757-9136  
Fax 225-752-7975  
P.O Box 80198  
Baton Rouge, LA 70898  
jimmyhill@fibersoils.com

**DAVID CHILL**  
Office 423-877-9550  
Fax 423-877-9180  
P.O Box 17455  
Chattanooga, TN 37415  
davidchill@fibersoils.com

**Toll Free 1-866-FIBERS1**