TECHNICAL NOTE

GEOSYNTHETIC REINFORCEMENT AND SEPARATION

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The Federal Highway Administration (FHWA) Geosynthetics Engineering Manual (Holtz et al., 1998) lists four functions of geosynthetics in pavements structures that may be in effect in a given structure: **separation, filtration, drainage, and reinforcement**. The benefits listed in the FHWA manual have been verified both through research and design methods supported by over 30 years of experience. The GMA White Paper II, June 27, 2000, defines these functions during the performance life of the roadway structure as;

- Separation - prevention of subgrade soil intruding into aggregate base (or sub-base), and prevention of aggregate base (or sub-base) migrating into the subgrade.
- Filtration - restricting the movement of soil particles, while allowing water to move from the filtered soil to the coarser soil adjacent to it.
- Lateral Drainage (i.e., transmission) -the lateral movement of water within the plane of the geosynthetic.
- Reinforcement - the addition of structural or load-carrying capacity to a pavement system by the transfer of load to the geosynthetic material.

Separation

In geotechnical engineering, the alternative to utilizing a separation geotextile is to incorporate an additional soil layer, which can be cost prohibitive. The requirements for a separation geotextile at the subgrade-base course interface are well documented and can be listed as follows:

- Retention: The separation geotextile must have an opening size small enough to prevent the migration of subgrade fines into base course under dynamic vehicle loads.
- Permeability: The number of openings and their size in the separation geotextile must be large enough not to adversely affect the flow of liquid or air in either a downward or an upward direction.
- Survivability: The geotextile must possess adequate strength and a construction suitable to survive installation and in-service conditions. **(GRI)**

Retention and permeability requirements relate to the geotextile's apparent opening size and opening distribution. Survivability, on the other hand, is a function of the strength and flexibility of the geotextile.

Quantifying Separation

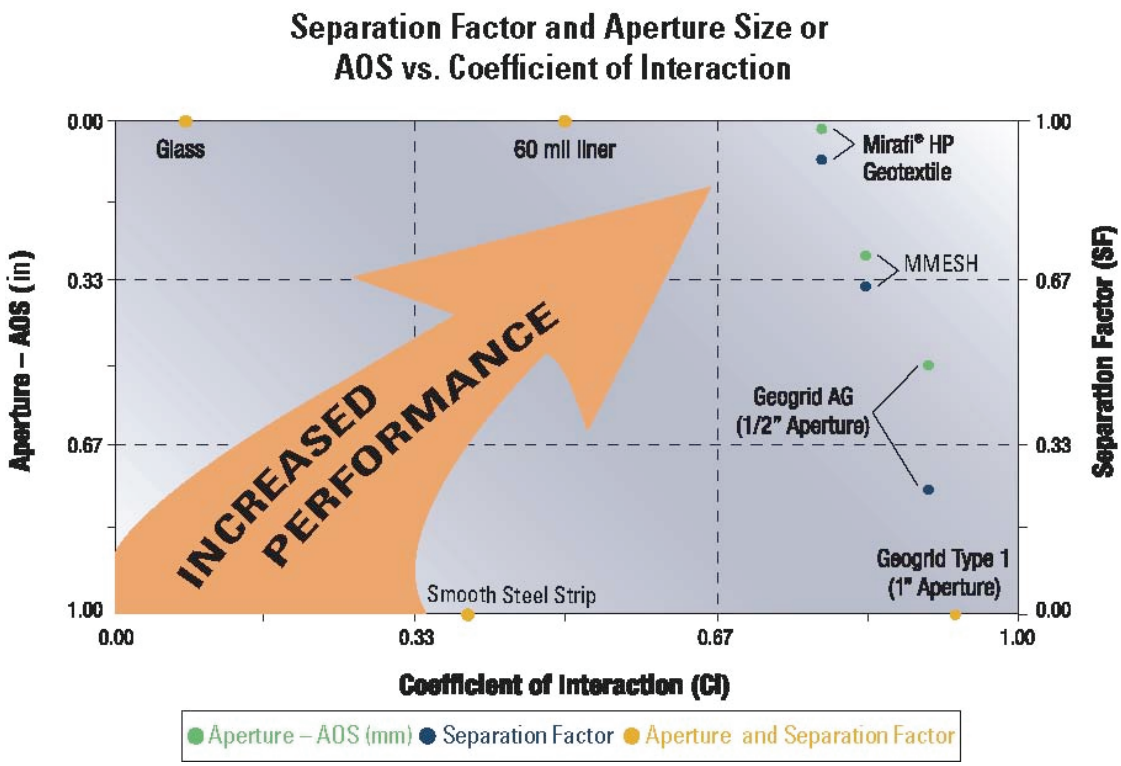
For the past 30 years, engineers have known that Separation was a key geosynthetic function. However, until recently, the Separation function could not be quantified. Today with the emergence of the Separation Factor, engineers can now quantify a products ability to separate.

Definition of Separation Factor

The separation factor (SF) for a specific geosynthetic with respect to a given soil is defined as the ratio of the soil mass retained (M_R) on top of a geosynthetic sieve to the total soil mass (M_T) in this study. The separation factor (SF) can be calculated using the following equation:

$$SF = M_R / M_T$$

and can be analyzed relative to other measurable indexes, primarily the coefficient of interaction (confinement) and AOS (filtration).



So, is the Separation Factor a property that should be specified? Absolutely.

As with all geosynthetic products, key properties define the products ability to be used, and used well, in a particular application. For years, we have specified quality control properties such as tensile strength, puncture, burst, etc. in a round-about way to specify separation. The use of the Separation Factor finally gives us a way to truly quantify the separation ability of the geosynthetic material.

Reinforcement

Geosynthetic reinforcement can be defined in terms of the specific application in roadways;

- **Pavement System Reinforcement** - Use of a geosynthetic to aid in support of traffic loads, where loads may be vehicular loads over the life of the pavement, or construction equipment loads on the unpaved base course or sub-base during construction.
- **Base Reinforcement** - Base (or sub-base) reinforcement may occur when a geosynthetic is placed as a tensile element at the bottom of a base (or sub-base) or within a base course to: (1) improve the service life and/or; (2) obtain equivalent performance with a reduced structural section. The mechanisms of reinforcement leading to these two benefits are described in detail in Section 2.4. Base reinforcement is applicable for the support of vehicular traffic over the life of the pavement and is designed to address the pavement distress mode of permanent surface deformation or rutting and asphalt fatigue cracking.
- **Subgrade Restraint** - Subgrade restraint may occur when a geosynthetic is placed at the subgrade/sub-base or subgrade/base interface to increase the support of construction equipment over a weak or low subgrade. The primary mechanism with this application is increased bearing capacity, although lateral restraint and/or tension membrane effects may also contribute to load carrying capacity. Subgrade restraint is the reinforcing component of stabilization. **(GMA- White Paper II, June 27, 2000)**

Quantifying Reinforcement

Originally, geosynthetic strength properties were measured in terms of textile testing methods (first geosynthetics were all textiles), e.g., Grab Tensile Strength (ASTM D-4632), reported as a force (pounds or newtons). As the industry progressed and the requirment for more design applicable data developed, the need arose for strength measurements that could provide tensile stiffness. These design parameters are commonly determined using the wide-width tensile test (ASTM D 4595).

In solid mechanics, **Young's modulus (E)** is a measure of the stiffness of a given material and is typically reported in terms of force per cross-sectional area, pounds per square inch (psi) or kilonewtons per square meter (kN/m^2). Geosynthetic modulus is defined as the ratio, for small strains, of the rate of change of stress with strain, such as the pound strength at a given elongation and is reported as force per width, such as lbs/foot width. A typical stress/strain curve is shown in Figure 1.

In the analysis of geosynthetic reinforced pavements, tensile forces are mobilized in the geosynthetic through deformation of the subgrade. As these tensile forces are developed, the amount of deformation of the geosynthetic and therefore the subgrade, are dependent on the modulus characteristics of the geosynthetic. In order to minimize the depth of rutting within the aggregate, the use of a geosynthetic that achieves high tensile strengths at low strains (higher modulus) is imperative.

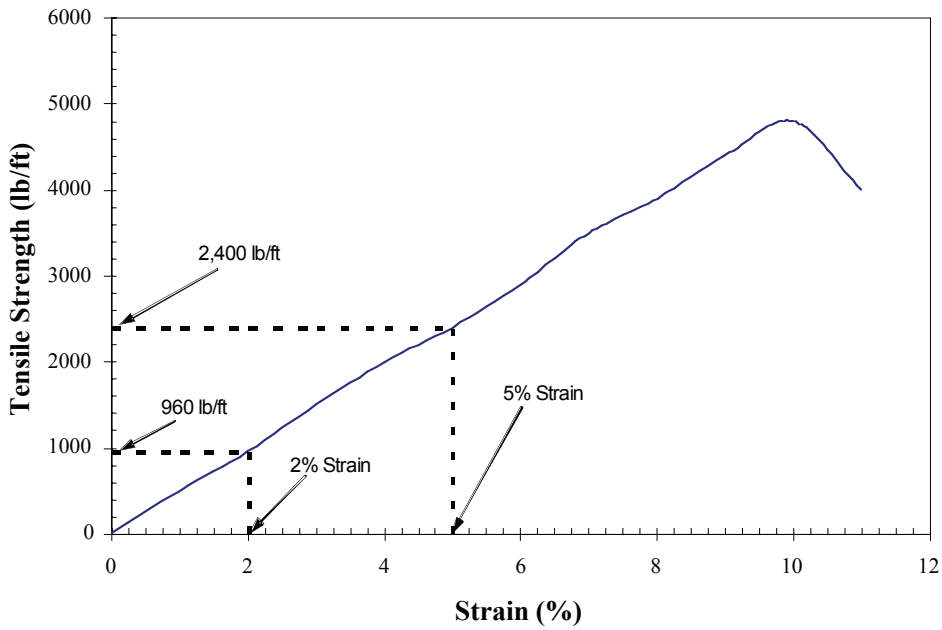


Figure 1

Best of Both Worlds

Geogrids are formed from plastics sheets and strips or woven from high tenacity yarns into a very open, grid like configuration, i.e., they have large apertures. They may be coated with polymers to provide additional protection. Geogrids function almost ***exclusively*** as reinforcement materials.

Geotextiles consist of synthetic fibers rather than natural ones such as cotton, wool, or silk. Thus biodegradation is not a problem. These synthetic fibers are made into a flexible, porous fabric by standard weaving machinery or are matted together in a random, or nonwoven, manner. The major point is that they are porous to water flow across their manufactured plane and also within their plane, but to a widely varying degree.

In the past, the need for separation and reinforcement has been accomplished by using a geogrid (reinforcement but no separation) and a non-woven geotextile (separation but no reinforcement). Today, these two key functions are can be accomplished in one layer of a High Performance, polypropylene geotextile. A High Performance geotextile is typically defined as a polypropylene geotextile that has an ultimate tensile strength greater than or equal to 35 kN/m (200 lbs/in) per ASTM D 4595. See Figure 2. However, the tensile modulus (strength at low strains) is the real key to the performance. One benefit of geogrids and high performance geotextiles is that they both provide this high strength at low tensile strains. However, geogrids are not able to provide the additional benefit of separation due to their construction.

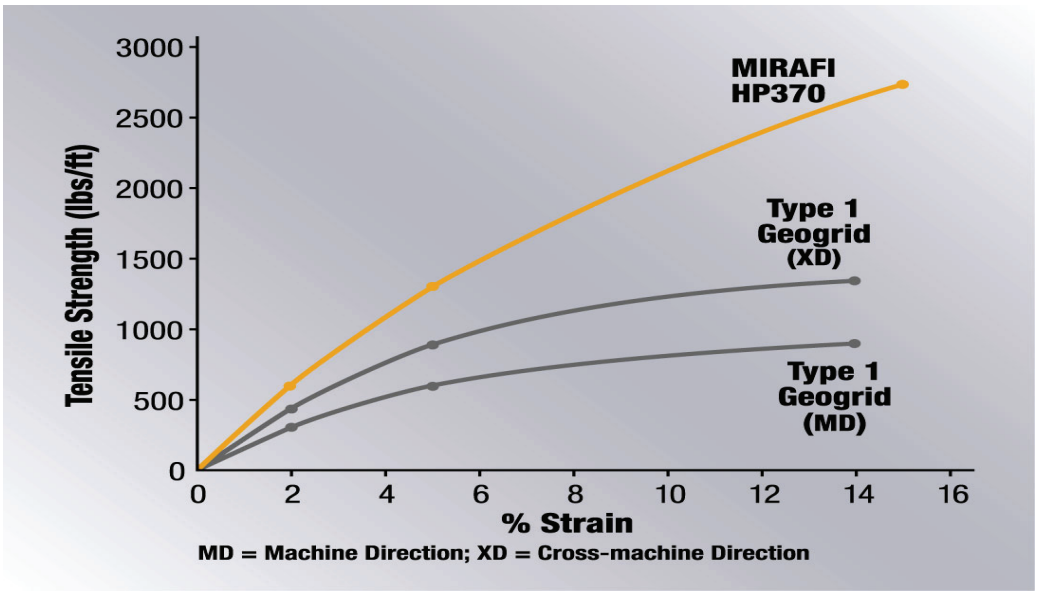


Figure 2

High tensile modulus values allow the high strength geotextile to quickly mobilize its strength and transfer this strength to soil. Many different types of geotextiles can meet the required 35 kN/m at ultimate to be classified as a high performance geotextile. However, recent studies show that in the critical strain levels approaching 6%, geosynthetics manufactured from high modulus polypropylene yarns, such as **Mirafi® HP370** and **Mirafi® HP570**, yield modulus strengths 50% to 250% higher than lightweight woven slit-film geotextiles. In addition, **Mirafi® HP370** and **Mirafi® HP570** also demonstrate an excellent balance of high tensile strength at low strains in **both** principle directions. Many other hybrid geotextile products only have excellent stress-strain characteristics in the cross direction, but performed poorly in the machine direction. These results can be attributed to the lack of high modulus yarns in the machine direction as well as the nature of the weave used to construct these products. Additionally, HP-Series geotextiles can provide very good hydraulic properties to aid with filtration and drainage requirements of a pavement structure.

As show in the chart below, Mirafi HP high performance geotextiles provide both high reinforcement and separation.

Geosynthetic Selection Guidelines

Function/Product	HP 570	BasXgrid 12	HP 370	BasXgrid 11	HP 270
Separation	Excellent	Poor	Excellent	Poor	Excellent
Reinforcement	Very High	Very High	High	High	Moderate
Water Flow Capacity	High	N / A	High	N / A	High
Survivability	Very High	Very High	High	High	Moderate

In addition, TenCate Geosynthetics provides formatted specifications for these high performance geotextiles. Go to our website at www.mirafi.com, click on technical data, and then CSI Specifications.