DURABILITY OF HIGH-STRENGTH GEOSYNTHETICS

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Durability is a major issue for all polymeric materials, including geosynthetic-reinforcing materials such as Miragrid® geogrids and high-strength woven geotextiles, when long design lifetimes are required. Degradation of a polymeric material typically results in a loss of strength. All generally accepted soil reinforcement design procedures require that this potential strength loss be accounted for in the determination of the reinforcing material's long-term design strength.

The purpose of this technical note is to discuss the relation between the potential affect of chemical and biological degradation and the partial reduction factor for durability, RFD, used in the calculation of the long-term design strength of Miragrid® geogrids and high-strength woven geotextiles.

Geosynthetic Durability - Background Studies

Geosynthetics, like all other construction materials, will degrade over time. The rate of degradation will depend on the molecular make-up of the geosynthetic polymer and the nature of the environment to which the geosynthetic is exposed. Since most geosynthetics are buried in non-aggressive soil environments, geosynthetic degradation normally occurs at a very slow, almost unmeasureable, rate. Still, it is possible for significant rates of degradation to take place if unstable polymers are used or extreme conditions are encountered as described in subsequent sections.

The partial reduction factor for durability, RFD, is derived from testing. Figure 1 compiles the reduction factors associated with durability testing reported by Salmon, et al (1997); Elias, et al (1998); Schmidt, et al (1994); Jailloux, et al (1992) and Risseeuw (1990); and Burgoyne and Merii (1993). These reduction factors are compared with the more conservative FHWA/Industry guidelines based on Elias, et al (1997) and IFAI (1997). TenCate Geosynthetics were included in several of the referenced tests.

Average Reduction Factors, RFD, from Testing High-Strength PET FHWA/Industry Guidelines for PET in the Absence of Product-Specific Testing

Max. Reduction Factors, RFD, from Testing PP & PE and FHWA/Industry Guidelines for PP & PP

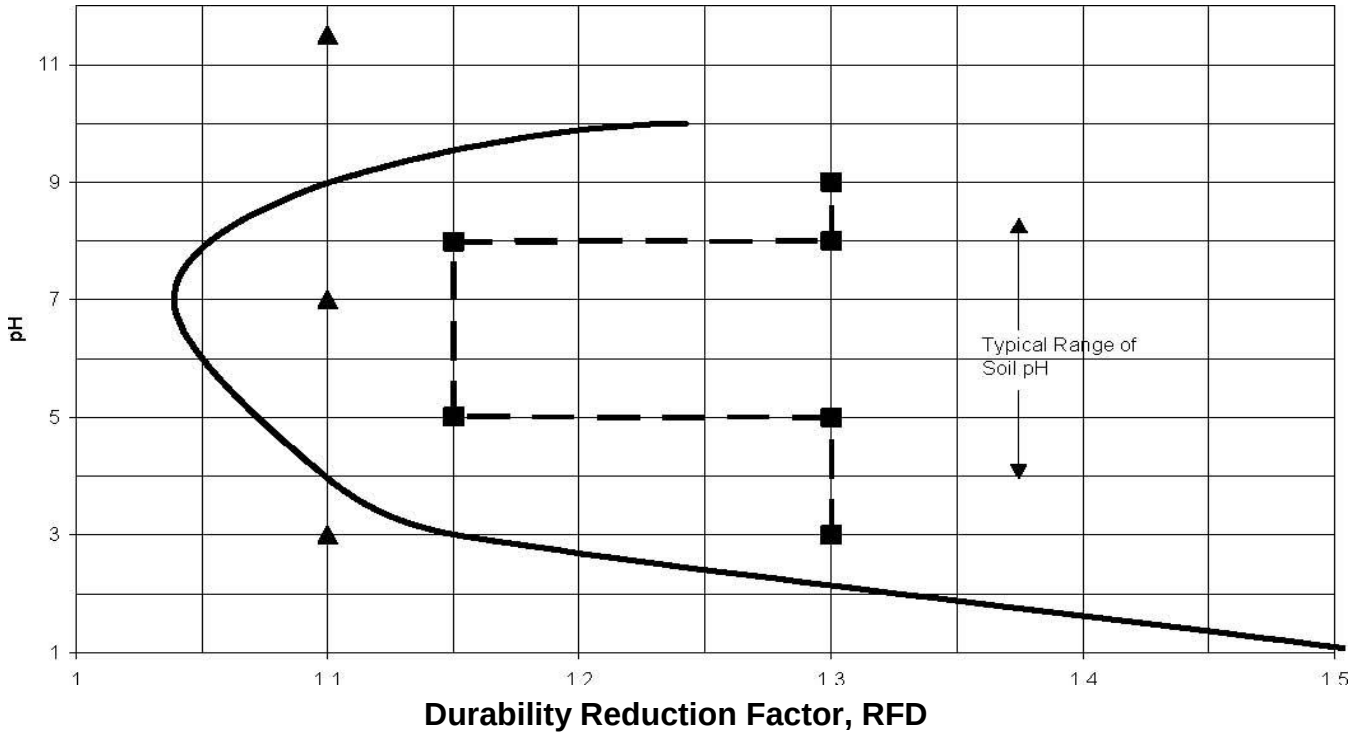

Figure 1. Durability Reduction Factors, RFD, for High Strength Geosynthetics @ 75 Years Durability of TenCate Geosynthetics

As long as polymer stability can be demonstrated and the anticipated soil environment is typically nonaggressive, it is common to use a “default” partial reduction factor for durability, RFD. The FHWA / geosynthetics industry has given some conservative guidance on the selection of the RFD in the absence of product-specific testing (see Figure 1 and Table 3). Yet, specific product testing and field experience has demonstrated that the RFD values shown in Table 1 are commonly applicable to TenCate geosynthetics and are allowed by industry guidelines.

Table 1. Recommended RFD for TenCate Geosynthetics in Typical Soils (4 ≤ pH < 8.5)

Geosynthetic Type	Min. Criteria (see Table 2)	RFD
Woven Polyester (PET) Geotextiles	Mn>25,000; CEG<30	1.1
Woven/Coated Polyester (PET) Geogrids	Mn>25,000; CEG<30	1.1
Woven Polypropylene (PP) Geotextiles	70% Retained after 500 Hrs	1.1

Defining Stable Polymers

Numerous studies have been conducted over the last four decades to assess the degradability of various polymers, including extensive evaluations of polyester, polypropylene, and polyethylene - the most common polymers used in geosynthetics. These studies have demonstrated that, when buried in soil environments, polypropylene and polyethylene degrade through a process called oxidation while hydrolysis is the degradation process for polyesters. A recent FHWA sponsored study found that, while the degradation of polypropylene and polyethylene can be controlled by adding anti-oxidants to the polymer, polyester can be made hydrolysis resistant by increasing its molecular weight above and reducing its number of carboxyl end groups below threshold levels. Table 2 details the threshold criteria for reinforcing geosynthetics that define them as stable for typical reinforcing applications. Table 3 provides conservative default reduction factors for geosynthetics with no other product-specific testing.

Table 2. Criteria for Using Default RFD based on FHWA/Industry Guidelines

Polymer Type	Property	Test Method	Criteria for Default RFD
Polypropylene	Oxidation Resistance	ASTM D4355	Min. 70% strength retained after 500 hrs. in weatherometer
Polyethylene	Oxidation Resistance	ASTM D4355	Min. 70% strength retained after 500 hrs. in weatherometer
Polyester	Hydrolysis Resistance	GRI GG8	Min. Number (Mn) Molecular Weight of 25,000
Polyester	Hydrolysis Resistance	GRI GG7	Max. Carboxyl End Group Number of 30

Table 3. Default Partial Reduction Factors for Durability, RFD

Geosynthetic Type	3 < pH ≤ 5	5 < pH < 8	8 ≤ pH < 9
Polyester - Mn<25,000; CEG>30	2.0	1.6	2.0
Polyester - Mn>25,000; CEG<30	1.3	1.15	1.3
Polypropylene	1.1	1.1	1.1
Polyethylene	1.1	1.1	1.1

Extreme Environments

The partial reduction factor for durability is dependent on the soil environment, as well as on the geosynthetic polymer, as shown in Table 3. The soil presents a complex environment that is usually non-aggressive. However, all (or "most") polymers, including polypropylene and polyethylene, may experience acceleration in the rate of degradation under certain extreme conditions. For instance, extreme soil environments that may accelerate the degradation of polypropylene and polyethylene contain acid-sulfates or transition metals in high concentrations. Saturated, high pH soils may adversely affect polyester, but, according to Allen and Elias (1996), the degradation rate decreases as the temperature and/or humidity decreases, as the polymer molecular weight increases, and as the polymer carboxyl end group content decreases.

Durability of TenCate Geosynthetics

In an effort to provide quality reinforcement products with high durability in all soil environments, TenCate uses very high molecular weight and low carboxyl end group, high-tenacity polyester in the manufacture of our high-strength geotextiles and geogrids for soil reinforcement applications. TenCate has conducted product-specific testing in common and extreme environments. For common soil environments TenCate recommends a durability reduction factor, RFD, of 1.1 as shown in Table 1. Because of the many variables such as temperature, humidity, and pH that may contribute to an "extreme soil environment" condition, TenCate recommends that you contact us directly for our recommendations on appropriate durability reduction factors for unusual project-specific conditions that may be considered aggressive.

References

Allen, T.M. and Elias, V. (1996), “Durability of Geosynthetics for Highway Applications – Interim Report”, FHWA-RD-95-016.

Burgoyne, C.J. and Merii, A.L., (1993) “Hydrolysis Tests on Polyester Yarns”, Technical Report No. CUED/D-Struct/TR 138, Cambridge University, Department of Engineering, Cambridge, United Kingdom, 83 p.

Elias, V., DiMaggio, J.A., and DiMillio, A. (1997) “FHWA Technical Note on the Degradation-Reduction Factors for Geosynthetics”, Geotechnical Fabrics Report, August, pp. 24-26.

Elias, V., Salman, A., and Goulias, D., (1998), “The Effect of pH, Resin Properties, and Manufacturing Process on Laboratory Degradation of Polyester Geosynthetics”, Geosynthetics International, Vol. 5, No. 5, pp. 459-490.

IFAI (1997) “Industry Response to FHWA Technical Note”, Geotechnical Fabrics Report, August, pp. 27.

Interim Draft Report, “Durability of Geosynthetics for Highway Applications,” Tasks D and E, DTFH 61-91-R-00054.

Jailloux, J-M., Anderson, P.L., and Thomas, R.W. (1992) “Chemical-Compatibility Studies of Polyester Filaments and Yarns to be Used in Geocomposites. Phase 1: Tests at 95°C”, Journal of Geotextiles and Geomembranes, Vol. 11, pp. 277-290.

Risseeuw, P., and Schmidt, H.M., (1990) “Hydrolysis of HT Polyester Yarns in Water at Moderate Temperatures”, Proc. of the 4th Int’l Conf. on Geotextiles, Geomembranes and Related Products, Balkema, Vol. 2, The Hague, The Netherlands, pp. 691-696.

Salman, A., Elias, V., Juran, I., Lu, s. and Pierce, E. (1997) “Durability for Geosynthetics Based on Accelerated Laboratory Testing,” Geosynthetics ’97 Conference Proceedings, Industrial Fabrics Association International, St. Paul, MN, pp. 217-234.

Schmidt, H.M., te Pas, F.W.T., Risseeuw, P., and Voskamp, W. (1994) “The Hydrolytic Stability of PET Yarns Under Medium Alkaline Conditions”, Proc. of the 5th Int’l Conf. on Geotextiles, Geomembranes and Related Products, Vol. 3, Singapore, pp. 1153-1158.

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