TENCATE

Mirafi® PET Geotextiles

Properties of Mirafi® PET Geotextiles

Property		Unit	PET 200-50	PET 300-50	PET 400-50	PET 600-50	PET 800-50
Initial Mechanical Properties							
Characteristic initial strength, T_u (ISO 10319)	MD	kN/m	200	300	400	600	800
Characteristic initial strength (ISO 10319)	CD	kN/m	50	50	50	50	50
Characteristic initial strength at 5% strain (ISO 10319)	MD	kN/m	100	150	200	300	400
Strain at initial strength	MD	%	8	8	8	8	8
Material reduction factor creep-rupture, f_{cr}							
at 10 years design life			1.37	1.37	1.37	1.37	1.37
at 50 years design life			1.40	1.40	1.40	1.40	1.40
at 100 years design life			1.43	1.43	1.43	1.43	1.43
Creep limited strength based on creep-rupture, T_{CR}							
at 10 years design life		kN/m	146	219	292	438	584
at 50 years design life		kN/m	143	214	286	429	571
at 100 years design life		kN/m	140	210	280	420	559
Material reduction factor installation damage, f_{id}							
in clay, silt or sand			1.15	1.15	1.10	1.10	1.10
Material reduction factor environmental effects (4 < pH < 9), f_{en}							
at 10 years design life			1.00	1.00	1.00	1.00	1.00
at 50 years design life			1.03	1.03	1.03	1.03	1.03
at 100 years design life			1.05	1.05	1.05	1.05	1.05
Long term design strength in clay, silt or sand, T_D							
at 10 years design life		kN/m	127	190	265	398	531
at 50 years design life		kN/m	121	181	252	379	504
at 100 years design life		kN/m	116	174	242	364	484
Norminal roll width		m	5	5	5	5	5
Norminal roll length		m	100	100	100	100	100
Estimated roll weight		kg	230	320	420	590	770

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TENCATE GEOSYNTHETICS

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Mirafi® PET Geotextiles

Properties of Mirafi® PET Geotextiles

Property		Unit	PET 1000-50	PET 1200-50	PET 1400-50	PET 1600-50	PET 2000-50
Initial Mechanical Properties							
Characteristic initial strength, T_u (ISO 10319)	MD	kN/m	1000	1200	1400	1600	2000
Characteristic initial strength (ISO 10319)	CD	kN/m	50	50	50	50	50
Characteristic initial strength at 5% strain (ISO 10319)	MD	kN/m	500	600	700	800	1000
Strain at initial strength	MD	%	8	8	8	8	8
Material reduction factor creep-rupture, f_{cr}							
at 10 years design life			1.37	1.37	1.37	1.37	1.37
at 50 years design life			1.40	1.40	1.40	1.40	1.40
at 100 years design life			1.43	1.43	1.43	1.43	1.43
Creep limited strength based on creep-rupture, T_{CR}							
at 10 years design life		kN/m	730	876	1022	1168	1460
at 50 years design life		kN/m	714	857	1000	1143	1429
at 100 years design life		kN/m	699	839	979	1119	1399
Material reduction factor installation damage, f_{id}							
in clay, silt or sand			1.10	1.10	1.10	1.10	1.10
Material reduction factor environmental effects ($4 < pH < 9$), f_{en}							
at 10 years design life			1.00	1.00	1.00	1.00	1.00
at 50 years design life			1.03	1.03	1.03	1.03	1.03
at 100 years design life			1.05	1.05	1.05	1.05	1.05
Long term design strength in clay, silt or sand, T_D							
at 10 years design life		kN/m	664	796	929	1062	1327
at 50 years design life		kN/m	630	756	883	1009	1261
at 100 years design life		kN/m	605	726	848	969	1211
Norminal roll width		m	5	5	5	5	5
Norminal roll length		m	100	100	100	100	50
Estimated roll weight		kg	980	1180	1460	1640	980

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Design Strengths and Strains for TenCate Mirafi® PET Geotextiles

1. Mirafi® PET geotextiles design strengths and strains

Mirafi® PET high strength geotextiles are engineered materials suitable for short and long term soil reinforcement applications. They are composed of high modulus polyester yarns, assembled to form a directionally structured and stable geotextile that enables maximum load carrying efficiency.

Mirafi® PET high strength geotextiles are manufactured in a wide range of tensile strengths to suit different soil reinforcement conditions. Standard assessment procedures exist to determine the long term design strengths of Mirafi® PET high strength geotextiles. These rely on the application of material reduction factors to the initial tensile strength of the geosynthetic reinforcement in order to determine the appropriate long term design strength. For example, such procedures are standard practice in US Federal Highway Administration documentation and well-recognized Codes of Practice such as British Standard BS8006-1:2010.

The generic relationship for assessing the long term design strengths of geosynthetic reinforcements is shown below.

$$T_D = \frac{T_u}{f_{cr}\ f_{id}\ f_{en}} \qquad (1)$$

where,

- T_D is the long term design strength of the reinforcement;
- T_u is the initial tensile strength of the reinforcement;
- f_{cr} is the material reduction factor relating to creep effects over the required life of the reinforcement;
- f_{id} is the material reduction factor relating to installation damage of the reinforcement;
- f_{en} is the material reduction factor relating to environmental effects over the required life of the reinforcement.

The magnitudes of the material reduction factors f_{cr} and f_{en} are not only affected by time (the design life of the reinforcement) but also by temperature (the average in-ground temperature). In this datasheet a standard in-ground temperature of 20°C is used as the basis for measurement. This also agrees with in-ground conditions in many parts of the world and can also be considered to be conservative for colder climates.

2. Initial strengths and strains

All geosynthetic reinforcement materials should be described in terms of their characteristic initial strengths and not their mean initial strengths. This ensures the representation of initial tensile strength is statistically safe. The initial tensile strengths of Mirafi® PET high strength geotextiles shown at the front of this datasheet are expressed in terms of characteristic (95th percentile) values, which are statistically safe values.

The initial tensile loads and strains of Mirafi® PET high strength geotextiles can be represented by a single master curve covering all grades. This master curve is shown in Figure 1. Here the ordinate value is expressed as a percentage of the initial characteristic tensile strength. Because of the use of special high modulus PET yarns Mirafi® PET high strength geotextiles exhibit tensile loads of 50% of the initial tensile strength at only 5% strain which makes these materials very efficient in carrying tensile loads at relatively low strains.

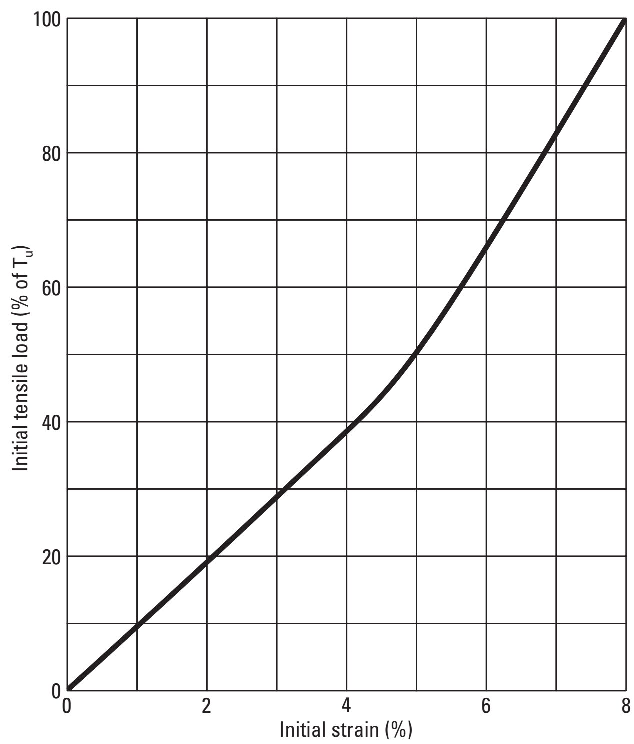

Figure 1. Initial tensile load – strain master curve for Mirafi® PET high strength geotextiles.

In prescribing suitable reinforcement strain limits to soil reinforcement applications reference is normally made to well-recognised Codes of Practice, e.g. BS8006-1:2010. Normally, for most soil reinforcement applications, reinforcement strains are limited to 5% or less over the design life of the reinforcement. Thus, the lower part of the tensile load – strain curve shown in Figure 1 (less than 5% strain) is the most important part of the curve when assessing allowable reinforcement strain levels.

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Design Strengths and Strains for TenCate Mirafi® PET Geotextiles

3. Material reduction factor for creep effects, f_{cr}

Creep effects can influence the behaviour of geosynthetic reinforcements in two ways – by decreasing the rupture load over time and by increasing the strain over time. Creep-rupture effects are associated with ultimate limit states (i.e. collapse modes) and are considered a critical case where basal reinforced embankments constructed on soft foundations are concerned. Creep-strain effects are associated with serviceability limit states (i.e. deformation modes) and may be critical where maximum reinforcement strains need to be limited and controlled.

3a. Material reduction factors for creep-rupture effects, f_{cr1}

The material reduction factor for creep-rupture f_{cr1} is derived from the creep-rupture curve of the geosynthetic reinforcement. The creep-rupture curve for Mirafi® PET high strength geotextiles is shown in Figure 2. This has been generated from a combination of long term (in accordance with ISO 13431) and accelerated creep testing (in accordance with ASTM D6992). For example, from Figure 2, the material reduction factor for creep-rupture at 100 yrs is f_{cr1} = 100%/70% = 1.43. Table 1 lists the creep-rupture material reduction factors for Mirafi® PET high strength geotextiles at 10 yrs, 50 yrs and 100 yrs design lives. Interpretation of the creep-rupture curve in Figure 2 can provide appropriate creep-rupture reduction factors for other reinforcement design lives.

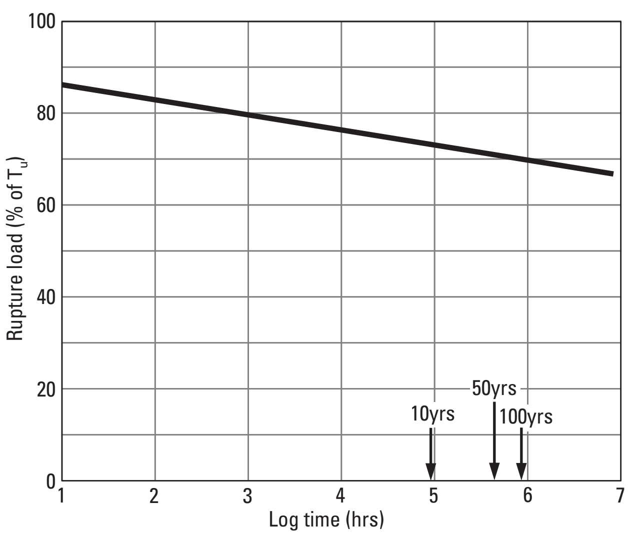

Figure 2. Creep-rupture curve at 20°C for Mirafi® PET high strength geotextiles.

Table 1. Material reduction factors f_{cr1} based on creep-rupture at 20°C for Mirafi® PET high strength geotextiles at three different reinforcement design lives.

	at 10 yrs	at 50 yrs	at 100 yrs
f_{cr1}	1.37	1.40	1.43

3b. Material reduction factors for creep-strain effects, f_{cr2}

The material reduction factor for creep-strain f_{cr2} is derived from the isochronous creep curves of the geosynthetic reinforcement. These curves show the change in strain of the reinforcement over time at different load levels. The isochronous creep-strain curves for Mirafi® PET high strength geotextiles are shown in Figure 3. The isochronous curves show that Mirafi® PET high strength geotextiles exhibit low creep strains over long design lives.

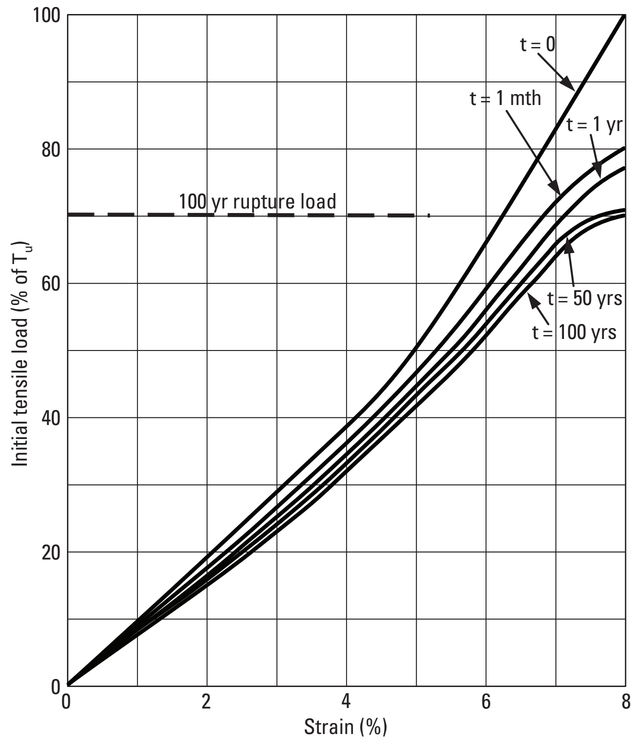

Figure 3. Isochronous creep-strain curves at 20°C for Mirafi® PET high strength geotextiles.

For example, if a design requires the total reinforcement strain to be limited to a maximum of 5% strain over a 100 year design life, then from Figure 3 a load level of 42% over 100 years will meet this requirement for Mirafi® PET high strength geotextiles. Thus, f_{cr2} = 100%/42% = 2.38.

In some cases, it may be required to limit the post-construction strain in the reinforcement to, say, 1% in order to prevent long term deformations in a reinforced soil structure. In this case the t = 1 mth curve shown in Figure 3 can be used as a good approximation of the time it takes to construct the structure, and if the design life is 100 years and the maximum creep-strain has to be limited to 1%, then a maximum load level of around 65% can be sustained. Thus, here f_{cr2} = 100%/65% = 1.54.

Design Strengths and Strains for TenCate Mirafi® PET Geotextiles

3c. When to use f_{cr1} or f_{cr2} for the value f_{cr} in Equation 1

Whether to use f_{cr1} or f_{cr2} for the value f_{cr} in Equation 1 depends on the design method being used as well as the type of analysis being undertaken.

Where a design method based on a global factor of safety approach is being used then values of f_{cr1} based on reinforcement creep-rupture should be used as the value of f_{cr} in Equation 1.

Where a design method based on a limit state approach is being used then both f_{cr1} and f_{cr2} should be used as the value of f_{cr} in Equation 1 depending on whether an ultimate limit state analysis or a serviceability limit state analysis is being performed. In an ultimate limit state analysis f_{cr1} should be used as the value for f_{cr}, whereas in a serviceability limit state analysis f_{cr2} should be used as the value for f_{cr} in Equation 1.

4. Material reduction factor for installation damage effects, f_{id}

When the reinforcement is installed and fill is compacted against it, some loss in initial strength can be experienced by the reinforcement. This loss in strength due to installation damage is accounted for by use of a material reduction factor, f_{id}. The magnitude of the material reduction factor for installation damage effects depends on the reinforcement structure and the type of fill being compacted against the reinforcement. Normally, installation damage tests are carried out on sites, in accordance with established methods such as ASTM D5818 or BS8006-1:2010 Annex D, using different fill types.

Mirafi® PET high strength geotextiles exhibit material reduction factors for installation damage, the magnitude of which depends on the grade of product and the type of fill used. For example, when clay, silt or sand fill is compacted against Mirafi® PET high strength geotextiles values of f_{id} range from 1.10 to 1.15. For coarser fills the material reduction factor will be greater.

5. Material reduction factor for environmental effects, f_{en}

The chemical inertness of the high modulus PET yarns used in Mirafi® PET high strength geotextiles makes them highly durable when installed in a wide range of soil environments. For PET reinforcement to be used for long term design lives (100 years) the US Federal Highway Administration recommends that the PET molecular weight ≥ 25,000 g/mol and Carboxyl End Group count ≤ 30 mmol/kg. Mirafi® PET high strength geotextiles surpass these requirements.

Long term environmental testing in pH conditions ranging from 4 < pH < 9 at 20°C yield the material reduction factors listed in Table 2 for Mirafi® PET high strength geotextiles.

Table 2. Material reduction factors based on environmental effects at 20°C for Mirafi® PET high strength geotextiles at three different reinforcement design lives.

	at 10 yrs	at 50 yrs	at 100 yrs
f_{en}	1.00	1.03	1.05

6. Bond Resistance - direct sliding and pull-out

For geosynthetic reinforced soil structures the reinforcement must behave in a composite manner with the adjacent soil. To accomplish this there must be a good bond resistance developed between the reinforcement and the adjacent soil. Two different forms of bond resistance can arise – bond resistance due to direct sliding and bond resistance due to pull-out. Direct sliding occurs when a potential failure plane coincides with the surface of the reinforcement layer. Pull-out occurs when a potential failure plane intersects reinforcement layers at an inclined angle.

The effectiveness of the reinforcement bond resistance is governed by the magnitude of the interaction coefficient between the reinforcement and the adjacent soil and its bond length. Table 3 lists interaction coefficients for Mirafi® PET high strength geotextiles with three different soil types.

Table 3. Interaction coefficients for direct sliding and pull-out resistance for different adjacent fill types.

Interaction Coefficient	Silt or Clay	Sand	Gravel (≤ 50mm)
Direct shear, α_{ds}	0.7	0.8	0.9
Pull-out, α_{po}	0.7	0.8	0.9

References

ASTM D5818 : Standard practice for exposure and retrieval of samples to evaluate installation damage of geosynthetics.

ASTM D6992 : Standard test method for accelerated tensile creep and creep rupture of geosynthetic materials based on time-temperature superposition using the stepped isothermal method.

BS8006-1:2010 Code of practice for strengthened/reinforced soils and other fills, British Standards Institution.

ISO 13431 : Geotextiles and geotextile-related products-Determination of tensile creep and creep rupture behaviour.

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