TerraStop® HSW - High Strength Woven

Woven Range

High strength polyester fabrics ranging in strength from 100-1200kN/m suitable for solving complex engineering problems. They are used to reinforce soils where extremely high tensile strength with low elongation is required.

TerraStop® PET High Strength Woven Geotextiles are manufactured from high tenacity polyester (PET) yarns, knitted to form a structured matting.

TerraStop® PET High Strength Woven Geotextiles are manufactured by under ISO 9001. The design factors stated are based on manufacturers independent research and testing.
Product strength and stiffness are affected both by temperature and by rate or duration of loading. For these reason it's important that standard methods of tensile testing are used, so that temperature and strain rate are defined.

Designed for Civil Engineering applications such as:

- reinforcement of granular soils
- embankment reinforcement
- retaining structures
- basal reinforcement
- piling platforms
- subgrade improvement
- Slope stabilization

TerraStop® PET High Strength Woven Geotextiles, quality control (QC) tensile testing is carried out using the method given in International Standard BS EN ISO10319:1996. This is a wide width method with specimen width of 200mm. Strain rate is 20% per minute and test temperature is 20°C.

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PROPERTIES	SYMB	UNIT	TerraStop® PET (H) Woven Range								
			100/ 50	200/ 50	300/ 50	400/ 50	600/ 50	700/ 50	800/ 50	1000/ 100	1200/ 100
Ultimate Tensile Strength MD	Tu	kN/m	100	200	300	400	600	700	800	1000	1200
Elongation (+/- 2%)		%	<10	<10	<10	<10	<10	<10	<10	<10	<10
Characteristic tensile creep rupture strength @ 120 years	Tcr	kN/m	71.4	142.9	214.3	285.7	428.6	500.0	571.4	714.3	857.1
Characteristic initial tensile strength with maximum 5% strain	Tcs	kN/m	45.0	90.0	135.0	180.0	270.0	315.0	360.0	400.0	480.0

Note: The above HS Woven Range is typical. Other strengths can be made to order.

DESIGN FACTORS

Main Roads Departments and engineers derive their design strengths of geosynthetic reinforcement in accordance with Section 5.3.3, Annexure A and Annexure D of BS 8006 take into account the following requirements in BS 8006:
(A) Determining strength reduction factors and in calculating design strengths of geosynthetics.
(B) Comply with the following requirements in Section 5.3.3 and Annexure A of BS 8006.

DETERMINING STRENGTH REDUCTION FACTORS:

- Long term creep and durability (e.g. hydrolysis).
- Creep and creep rupture tests must be carried out in accordance with ISO 13431 or equivalent.
- Stress rupture characteristics; Chemical effects due to ground water and the type of fill; Temperature; Construction site installation damage; Deviations from the manufacturer's quality control strength; Pull out strength interaction values; and Connection strengths.

COMPLY WITH THE FOLLOWING REQUIREMENTS IN SECTION 5.3.3 AND ANNEXURE A OF BS 8006:

Maximum operating temperature must not be less than 20°C; and Maximum creep strain must not exceed 1% over a design life of 100 years at the maximum operation temperature in the derivation of Tcs.

- A summary of the Partial Material Factors are listed in Table 1(next page). Furthermore, the long term design strength of the connections (if required) in the longitudinal direction must be higher than the reinforcement.
- The factors and design parameters given hereafter represent a help/tool for pre-designing structures. These parameters and results are based on our experience and research. For each project, specific parameters must be evaluated with specific soil conditions and real project parameters by the official design office of the project, or a specific design office mandated.
- Durability of the TerraStop® PET High Strength Woven Geotextiles have been tested throughout the years. This evaluation is based on different raw results and data from official laboratory tests and official standards.

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TABLE 1. PARTIAL MATERIAL FACTORS FOR REINFORCEMENTS

Partial Factors		
Partial factor for - Material manufacture consistency & variations	f_{m11}	f_{m1}
Partial factor for - Extrapolation of test data to design life	f_{m12}	
Partial factor for - Susceptibility to damage during installation	f_{m21}	f_{m2}
Partial factor for - Environmental or chemical effects	f_{m22}	
Reinforcement material factor (f_m) = (f_{m11} x f_{m12}) x (f_{m21} x f_{m22})		f_m

CREEP RUPTURE

Creep Rupture properties were determined by independent testing authorities performing conventional creep tests to DIN EN ISO 13431-11: 2004 and accelerated SIM tests to ASTM D 6992- 2009 and ISO/TR 20432-=12.2007 on a variety of PET products.

A summary of the Creep Reduction Factors RFcr is listed in Table 2. The ratio of Tu from a direct Tensile Test to limit 5% at 120 years is 40%.This is the maximum tension allowed in the TerraStop® PET High Strength Woven Geotextile to limit deformation to 5% in 120 years.

TABLE 2. CREEP REDUCTION FACTORS

Service Life	Tensile Creep Rupture	Reduction factor RF_{creep}
< 5 years		1.35
< 10 years	Linear Regression MD = 73.9%	1.35
< 25 years	Linear Regression MD = 73.0%	1.37
< 50 years	Linear Regression MD = 72.3%	1.38
< 120 years	Linear Regression MD = 71.4%	1.40

INSTALLATION DAMAGE

Factors are derived from independent field and large scale laboratory tests. Values of f_{m21} for TerraStop® PET High Strength Woven Geotextiles placed on differing soils are listed in Table 3.

TABLE 3. INSTALLATION DAMAGE

Fine material Sand < 2mm	Gravel <50mm	Gravel >100mm
1.10	1.20	TBC

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DURABILITY - CHEMICAL RESISTANCE

TerraStop® PET High Strength Woven Geotextiles Hydrolysis ageing test was carried out to standard ISO/EN12447: 2003.Values of f_{m21} for TerraStop® PET High Strength Woven Geotextiles are listed in Table 4.

SCOPE:

Screening test method for determining the resistance to hydrolysis by exposing test specimens to water at elevated temperatures, followed by an evaluation of the changes in properties resulting from such exposure. In particular applicable to polyester and polyamide based materials, and in addition to the yarns from which these geotextiles are made.

TABLE 4. CHEMICAL RESISTANCE

pH range	Design lifetime (years)	Max temp. (°C)	Durability
2 to 5	120	25	1.30
5 to 8	120	25	1.10
8 to 11	120	25	1.30

Reinforcing materials shall be tested without the coating and manufacturers shall ensure that the degradation of the coating will not attack or have any negative influence on the degradation of the yarns. This method is not intended for determining the resistance of geotextiles to hydrolysis under highly acid or alkaline conditions.

Principle of test: Both test and control specimens are immersed in hot water for 28 days at 95°C. The properties of the specimens are determined after immersion.

Number of specimens: Five test specimens and five control specimens are tested and the results are expressed as a percentage of retained strength or elongation, compared to the reference specimens

FRICTION

TerraStop® PET High Strength Woven Geotextiles grades have been tested for friction properties with different soils to official standards.

TABLE 5. FRICTION PROPERTIES

Type of soil	Type of geosynthetic	Tan.phi .soil-Grid/Tan phi.Soil
For starting	"all grades"	0.70
Sand < 2mm	"light grades" < 150 kN/m	0.85
Sand < 2mm	"heavy grades" > 150 kN/m	0.95
Gravel 0/100mm	"light grades" < 150 kN/m	0.90
Gravel 0/100mm	"heavy grades" > 150 kN/m	0.95

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TYPICAL DESIGN

Ultimate Tensile Strength	T_u = Ultimate to ISO10319,
Characteristic short term tensile creep rupture strength	$T_{CR} = T_u / RF_{cr}$
Characteristic tensile strength at 120 years with maximum 5% strain (incl. max 1% creep strain	$T_{CS} = 0.4 \times T_{cr}$
Reinforcement material factor	$f_m = (f_{m11} \times f_{m12}) \times (f_{m21} \times f_{m22}\}$
Structure Classification Factor	SCF
Long term design strength for Ultimate Limit State	$TD = T_{cr} / (f_m \times SCF)$
Long term design strength for Serviceability Limit State	$TD = T_{cs} / (f_m \times SCF)$

	CHARACTERISTICS	SYMB	UNIT	TerraStop® PET (H) Woven Range								
				100/ 50	200/ 50	300/ 50	400/ 50	600/ 50	700/ 50	800/ 50	1000/ 100	1200/ 100
	Design											
Long Term 120 years	Ultimate Tensile Strength MD	T_u	kN/m	100	200	300	400	600	700	800	1000	1200
	Characteristic short term tensile creep rupture strength	T_{cr}	kN/m	71.4	142.9	214.3	285.7	428.6	500.0	571.4	714.3	857.1
	Characteristic tensile strength at 120 years with maximum 5% strain (incl. max 1% creep strain)	T_{cs}	kN/m	40.0	80.0	120.0	160.0	240.0	280.0	320.0	400.0	480.0
	Partial factor for - Material manufacture consistency & variability	f_{m11}		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Partial factor for - Extrapolation of test data to design life (SIM Method)	f_{m12}		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Partial factor for - Susceptibility to installation damage Table 3 Select Fill: silt, clay or sand	f_{m21}		1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
	Partial factor for - Environmental or chemical effects	f_{m22}		1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
	Reinforcement material factor = $(f_{m11} \times f_{m12}) \times (f_{m21} \times f_{m22})$	f_m		1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21
	Structure Classification Factor	SCF		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Long term design strength for Ultimate Limit State	TD	kN/m	59.0	118.1	177.1	236.1	354.2	413.2	472.3	590.3	708.4
	Long term design strength for Serviceability Limit State	TD	kN/m	33.1	66.1	99.2	132.2	198.3	231.4	264.5	330.6	396.7
Short Term < 5 years maximum	Ultimate Tensile Strength	T_u		100	200	300	400	600	700	800	1000	1200
	Characteristic short term tensile creep rupture strength	T_{cr}	kN/m	74.1	148.1	222.2	296.3	444.4	518.5	592.6	740.7	888.9
	Characteristic tensile strength at 5 years with maximum 5% strain	T_{cs}	kN/m	45.0	90.0	135.0	180.0	270.0	315.0	360.0	400.0	480.0
	Partial factor for - Material manufacture consistency & variability	f_{m11}		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Partial factor for - Extrapolation of test data to design life	f_{m12}		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Partial factor for -Susceptibility to installation damage Table 3 Select Fill: silt, clay or sand	f_{m21}		1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
	Partial factor for-Environmental or chemical effects	f_{m22}		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Reinforcement material factor = $(f_{m11} \times f_{m12}) \times (f_{m21} \times f_{m22})$	f_m		1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
	Structure Classification Factor	SCF		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Short term design strength for Ultimate Limit State	TD	kN/m	67.3	134.7	202.0	269.4	404.0	471.4	538.7	673.4	808.1
	Short term design strength for Serviceability Limit State	TD	kN/m	40.9	81.8	122.7	163.6	245.5	286.4	327.3	363.6	436.4

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