ACETex® // High Strength Woven PET Geotextile

The Challenge

Road and geotechnical design engineers are facing an increasing challenge throughout the Region of building roads, mining platforms and other infrastructure works on very problematic soils. Previous treatments might have involved very expensive excavation and replacement techniques, surcharging the site and waiting extended periods of time for increases in strength though pore water dissipation and consolidation or abandonment of the site option through cost. ACETex® provides engineers with a cost effective, proven alternative

Meeting the Challenge

Quality

Ace Geosynthetics have a commitment to using the latest technology in weaving processes that delivers highest strengths possible, at low soil compatible strains. Quality control within the manufacturing process ensures consistency of manufacture at all times. Ace Geosynthetics hold a number of internationally recognised accreditation approvals for their manufacturing processes.

Materials

Ace Geosynthetics use the best available polymers and the highest tenacity yarn to make the ACETex® product. Of importance is the choice of polymer used to make the ACETex® structural geotextile. Polyester polymer, in such applications of structural reinforcement, is the most resistant to loss of strength through creep effects over very long periods of time. The use of low carboxyl end group, high molecular weight, base polymer, has been proven to withstand the effects of hydrolysis and subsequent loss of strength in alkaline environments. Polyester polymer is the least susceptible to long term temperature effects.

Testing

Ace Geosynthetics have a commitment to fully understand the short term and long term behaviour of their product. Significant internal and external testing has been carried out at some of the world's most well recognised research and test facilities to independently verify product performance when subjected to physical damage, chemical resistance, load and temperature effects. Both real time and accelerated test methods have been performed to ensure that the ACETex® product performance is understood over design lives in excess of 120 years.

History

Ace Geosynthetics structural geotextile has been used for years on many Regional soil reinforcement projects with outstanding success. ACETex® geotextile is stocked locally with efficient lead times to suit construction requirements. ACETex® can be custom manufactured to suit specific project demands such as roll width or length. ACETex® product is supported in Australia, New Zealand and the South Pacific by Global Synthetic and GPIL engineers. ACETex® has been approved for use under the strict specification requirements of NSW R.M.S and QLD Department of Transport.

ACETex® PET structural geotextile
Coopernook Bypass Project
Coopernook, NSW

ACETex® PET structural geotextile
Northern Access Road Project
Brisbane, QLD

1. General

The ACETex® PET woven, high strength reinforcement geotextile range, are engineered products for applications of short term and long term soil reinforcement. The product is woven with strength in both the roll length direction (commonly called the machine direction-MD) and with strength manufactured in the cross roll direction (commonly called the cross machine direction-CD). Generally the strength of the product will be dominant in one direction of the roll (normally the MD) with sufficient strength in the other direction of the fabric (normally CD) such that the fibres are dimensionally stable and the roll may be easily deployed.

In applications of soil reinforcement the use of engineered geotextiles allows significant tensile strength to be imparted to soils. Soils are very weak in tension. The ACETex® PET geotextile effectively "bridges" potential failure planes behind or below structures that normally would require significant additional cost to construct. The use of soil reinforcement techniques has proven to be a very cost effective method of construction.

ACETex® PET woven geotextiles are manufactured from high tenacity polyester (PET) fibres with high molecular weights and low carboxyl end groups such that the product is suitable for use in normally occurring soil environments, for design lives in excess of 120 years. ACETex® PET woven geotextile is available in a range of strengths from 100kN/m to 1200 kN/m tensile strength.

2. Load assessment of ACETex®

The use of ACETex® PET woven geotextiles, in long term soil reinforcement applications, requires an assessment of the long term load carrying capabilities of the product.

The procedure adopted for ACETex® woven geotextiles follows a partial factor approach that accounts for influences of time, temperature, environment and load.

The assessment procedures for ACETex® PET woven geotextiles are compatible with US Federal Highway of Administration (FHWA), British Code of Practice BS8006:2010, EN ISO 20432:2007 and Australian Standard AS 4678. Australian Standards Handbook HB154-Geosynthetics-Guidelines on Durability may be read in conjunction with this data sheet.

The following procedure is an accepted method for determining the long term design strength of the reinforcement at differing design lives.

$$T_d = \frac{T_c}{f_c \cdot f_d \cdot f_e \cdot f_{m11} \cdot f_{m12}}$$

where,

T_d is the long term design strength of the reinforcement at the required design life.

T_c is the characteristic short term tensile strength of the reinforcement.

f_c is the partial factor relating to creep effects over the required design life of the reinforcement.

f_d is the partial factor relating to damage effects on the reinforcement.

f_e is the partial factor relating to environmental effects on the reinforcement.

f_{m11} is the partial factor relating to consistency of manufacture of the reinforcement.

f_{m12} is the partial factor relating to extrapolation of test data.

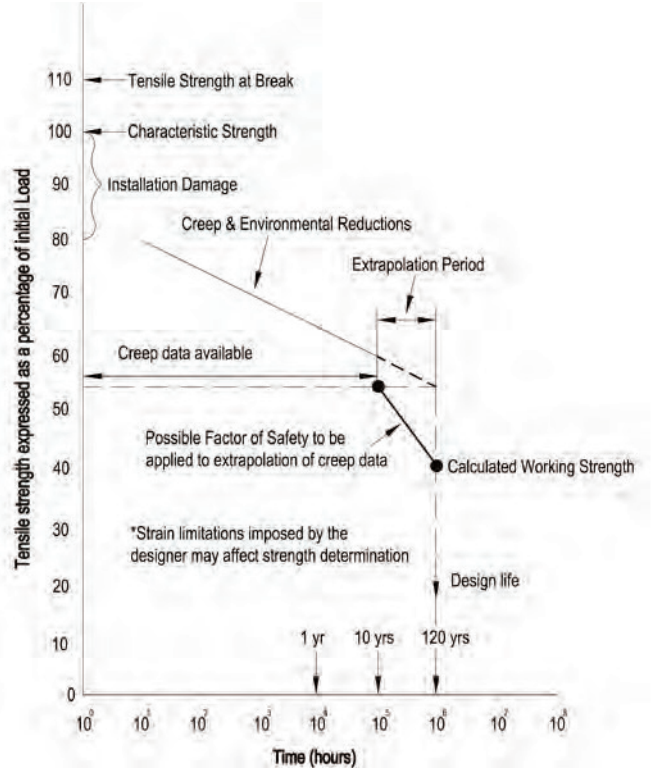

Fig. 1 Partial Factor Reductions

3. Partial factor relating to creep, f_c

In any assessment of the partial factor for creep, f_c, the creep rupture characteristics of the reinforcement must be known.
Significant independent testing has been carried out using both conventional creep rupture testing under long term loading conditions as well as accelerated test methods. From Fig.2 the values of fc can be obtained for different design lives. For example, at 60 years design life the ACETex® PET shows a 72% strength retention which equates to a partial factor of f_c= 1.38.

ACETex® PET woven geotextiles, being composed of high tenacity polyester fibres exhibit very low creep strains even at high tensile load levels. Creep strains of less than 1% over a 120 year design life at a design load of 40% of initial tensile strength are obtained.
The treatment of long term total and creep strains is referenced in Section 8 of this document. The reader is encouraged to carefully consider strain requirements and the effects on the allowable design strength of the geotextile.

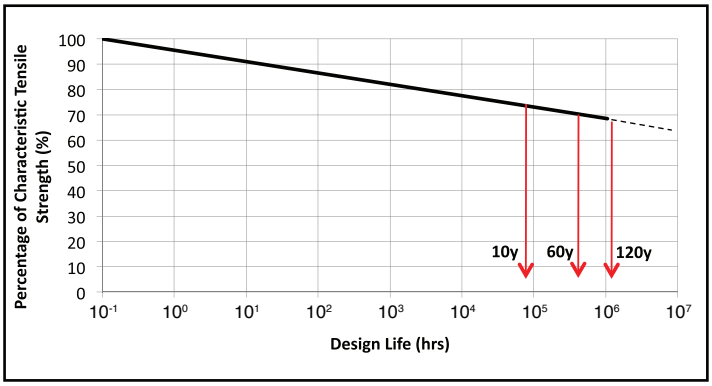

Fig.2 Creep Rupture Curve for ACETex® PET woven geotextiles

4. Partial factor relating to installation damage, f_d

The magnitude of damage, f_d, imposed upon the ACETex® PET woven geotextile is a function of the structure of the reinforcement, the aggressiveness of the fill placed either side of the reinforcement, the method of placement of the fill and the level of compaction performed. The damage factors used for ACETex® PET woven reinforcement products are derived from independent field and large scale laboratory tests. Values of f_d for ACETex® PET woven geotextiles placed in one soil environment are listed on this data sheet. Additional values for damage for more extreme soil environments may be obtained from GPIL.

5. Partial factor relating to environmental effects, f_e

The magnitude of the partial factor, f_e, is a function of the polymers used as well as the structure of the reinforcement. ACETex® PET woven geotextiles are manufactured from virgin, high tenacity polyester fibres. Polyester fibres have over many years demonstrated high resistance to strength loss when buried in soil environments for long periods of time. The ACETex® PET woven geotextiles are made of high molecular weight, low carboxyl end group fibres that are very stable in a range of pH environments. A range of partial factors, f_d, are given in the data sheet for a range of design lives in various environments.

6. Partial factor relating to consistency of manufacture, f_{m11}

ACETex® PET woven geotextiles are manufactured according to independently audited Quality Control and Assurance standards to meet a confidence level of 95% of the published tensile strengths. The partial factor adopted for ACETex® PET woven geotextiles for consistency of manufacture, **f_{m11}, has a value of 1.0 for design lives up to 120 years.**

7. Partial factor relating to extrapolation of creep data, f_{m12}

ACETex® PET woven geotextiles have been extensively tested both in real time creep testing and using time, temperature, shifting curves to account for long period of time. Both methods are carried out using ASTM and ISO test protocols. The examination of creep data and the suitability of use to extrapolate such data is referenced to BS8006.2010 and EN ISO 20432 2007. The partial factor based on the validity of the statistical envelope between real time testing and time temperature shifting methods (SIM) **allows f_{m12} to be assigned a value of 1.0 for design lives up to 120 years.**

8. Tensile strength strain properties

8.1 Short term tensile strength and strain with time = 0 hours

The short term tensile strength relationship to strain of ACETex® geotextile is shown as a master curve in Fig.4. The graph shows, as the "y" ordinate, the strength of the ACETex® geotextile as a percentage of the characteristic tensile strength. Thus one master curve may be used to represent all ACETex® grades available by converting the percentage values into actual strength values for individual grades. It is important to note that a relationship exists between strength, strain and time for all geosynthetic soil reinforcement. Isochronous stress curves (refer to Fig.5) must be used to calculate the long term design strength that will limit design strain for a given design life. Some manufacturers do not provide such information on data sheets which may lead to an over estimation of achievable geotextile strength for a long term design strain requirement.

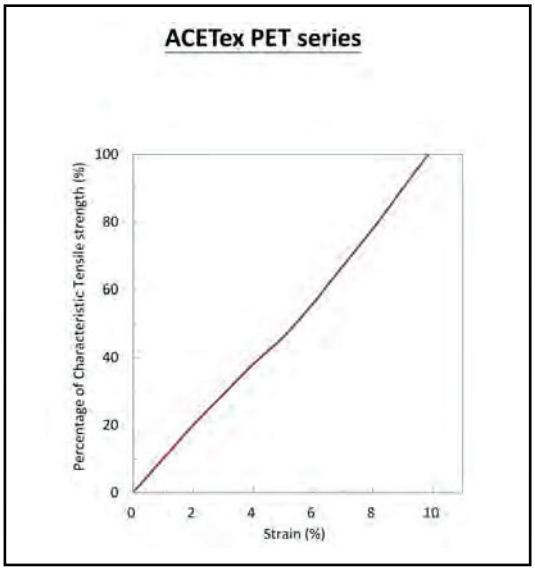

Fig. 4 Short term tensile strength-strain relationship for ACETex® geotextile.

8.2 Long term tensile strength and strain with time to 120 years

The long term tensile strength relationship to strain with the influence of time dependency for ACETex® geotextile is shown as a master curve in Fig.5. The graph shows, as the "y' ordinate, the strength of the ACETex® geotextile as a percentage of the characteristic tensile strength. The "x" axis is the strain component.

Superimposed upon the curves is the time relationship. A number of long term design lives have been plotted that allow the designer to limit the load within the geotextile such that a design strain limit is not exceeded for the structure to be constructed. Thus one master curve may be used to represent all ACETex® grades by converting the percentage values into actual strength values for individual grades. Shown below are the components of strain that are necessary to understand when specifying any structural soil reinforcement geosynthetic.

If we assume the construction phase duration as approximately 1 month, then under these circumstances, to limit the post construction strain to 1%, for a design life of 120yr, we consider the isochronous creep curve of the material at t=1mth and t=120yr. A maximum load level of 60% of the characteristic short term tensile strength, will satisfy this criteria.

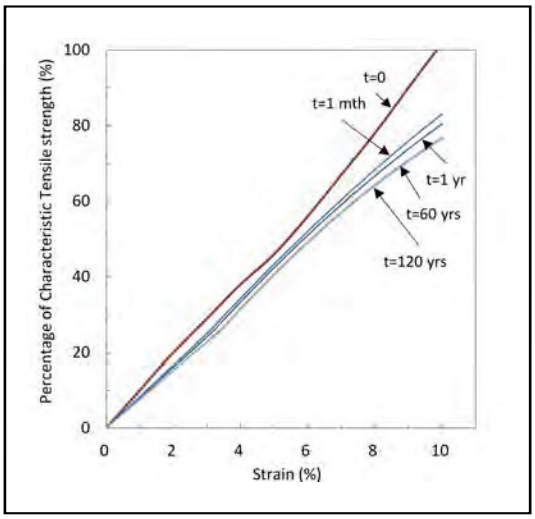

Fig. 5 Long term tensile strength-strain-time relationship for ACETex® geotextile-Isochronous curves.

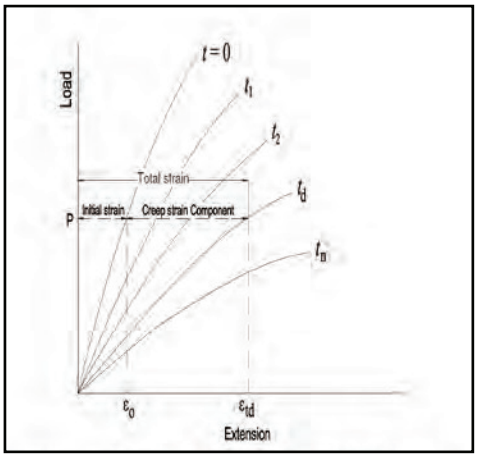

Fig.3 Method of determining the initial extension ε_0. The total extension ε_{td} over time period t_d.

PROPERTIES OF ACETex® PET WOVEN GEOTEXTILES

PROPERTY		UNITS	GT 100/50	GT 200/50	GT 300/50	GT 400/50	GT 500/50	GT 600/50	GT 800/50	GT 1000/50	GT 1200/100
MECHANICAL PROPERTIES											
Characteristic short term tensile strength	MD	kN/m	100	200	300	400	500	600	800	1000	1200
Characteristic short term tensile strength	CD	kN/m	50	50	50	50	50	50	50	50	100
ISO 10319											
Strain at short term strength ISO 10319	MD	%	10	10	10	10	10	10	10	10	11
Partial factor - creep rupture - f_c											
at 5 years design life			1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33
at 10 years design life			1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34
at 60 years design life			1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38
at 120 years design life			1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Creep limited strength											
at 5 years design life	MD	kN/m	75	150	226	301	376	451	602	752	902
at 10 years design life	MD	kN/m	74	149	224	299	373	448	597	746	896
at 60 years design life	MD	kN/m	72	145	217	290	362	435	580	725	870
at 120 years design life	MD	kN/m	71	143	214	286	357	429	571	714	857
Partial factor - construction damage - f_d in clay, silt or sand			1.1	1.1	1.1	1.05	1.05	1.05	1.05	1.05	1.05
Partial factor - environmental effects in soil environment 2 < soil pH < 10 - f_e											
not exceeding 10 years design life			1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
at 60 years design life			1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
at 120 years design life			1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
Long term design strengths - t_d in clay, silt or sand											
at 5 years design life	MD	kN/m	68	137	205	286	358	430	573	716	859
at 10 years design life	MD	kN/m	67	136	204	284	355	426	569	711	853
at 60 years design life	MD	kN/m	64	128	192	268	335	402	536	670	804
at 120 years design life	MD	kN/m	62	124	186	259	324	389	518	648	777
Nominal roll width		m	5	5	5	5	5	5	5	5	5
Nominal roll length		m	100	100	100	100	100	100	100	50	50

Long term design strength is determined by compounding the reduction factors for creep, installation, and environmental effects. ACETex is made from polyester yarn with high molecular weight, Mn > 30,000 and a Carboxyl End Group, CEG of <14 mmol/kg. ACETexs are resistant to all naturally occuring soil acids and alkalines, pH 2 - 10. Values quoted are statistically 95% confident and are described as the characteristic value. Testing on the product is carried out in a credited testing laboratories within factory and at third party accredited testing laboratories and institutions.

GEOSYNTHETIC PARTNERS INTERNATIONAL

Chris Brockliss
+64 21 270 3139
chrisbrockliss@gpil.co.nz

Laurie Vercoe
+64 21 936 730
laurievercoe@gpil.co.nz

www.gpil.co.nz

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