ACEGrid® // High Performance Coated Flexible PET Geogrid

The Challenge

Road and geotechnical design engineers are facing an increasing challenge throughout the Region of building roads, retaining structures and related structures with a wide range of soil types and over problematic soil conditions. Relatively low shear capacity soils benefit significantly with the inclusion of an appropriate geosynthetic. ACEGrid® provides engineers with a cost effective, proven alternative to the importation of expensive fills and allows structures to be built relatively economically than would normally be possible.

Meeting the Challenge

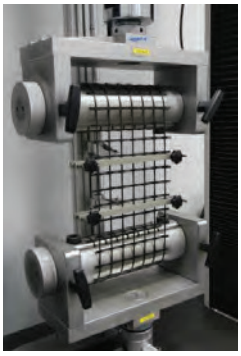
Quality

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 ACEGrid® product. Of importance is the choice of polymer used to make the ACEGrid® structural geogrid. 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.

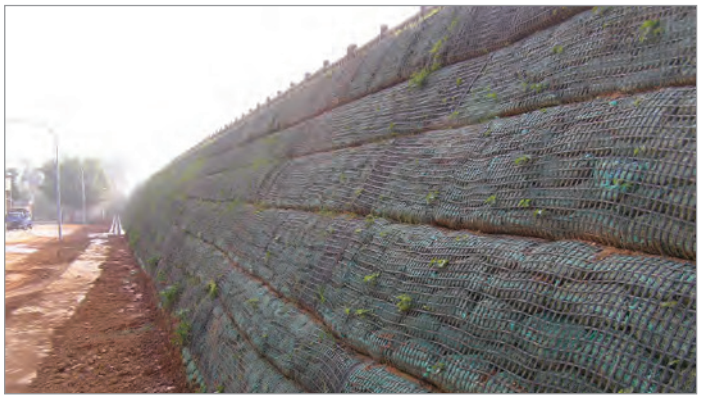
Testing



Ace Geosynthetics have a commitment to fully understand the short term and long term behavior 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 ACEGrid® product performance is understood over design lives in excess of 120 years.

History

Ace Geosynthetics high performance geogrid has been used for years on many Regional soil reinforcement projects with outstanding success. ACEGrid® geogrid is stocked locally with larger requirements made to order with speedy lead times to suit construction requirements. ACEGrid® can be custom manufactured to suit specific project demands such as roll width or length. ACEGrid® product is supported in Australia, New Zealand and the South Pacific by Global Synthetics and GPIL engineers. ACEGrid® geogrid has been approved for use under the NSW RMS R57 Specification process. Similarly this approval is accepted by the Queensland Department of Transport and Main Roads. International approvals are held with the product accredited with BBA (British Board of Agreement) for applications of basal and slope reinforcement. Product evaluations have been carried out in the USA through the AASHTO- NTPEP programme.



The use of ACEGrid® as a front wrapped reinforcement treatment and after completion showing the vegetated structure.

1. General

The ACEGrid® high performance geogrid range, are engineered products for applications of short term and long 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 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 ACEGrid® engineered geogrids allows significant tensile strength to be imparted to soils. Soils are very weak in tension. The use of soil reinforcement techniques has proven to be a very cost effective method of construction. ACEGrid® engineered geogrids 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 types, for design lives in excess of 120 years. ACEGrid® high performance geogrids are available in a range of strengths from 40kN/m to 900 kN/m tensile strength.

2. Load assessment of ACEGrid®

The use of ACEGrid® high performance geogrid, in long term soil reinforcement applications, requires an assessment of the long term load carrying capabilities of the product.
The procedure adopted for ACEGrid® high performance geogrid follows a partial factor approach that accounts for influences of time, temperature, environment and load.
The assessment procedures for ACEGrid® geogrids 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. There may be additional considerations in some design situations such as the need to satisfy appropriate connection criteria. Additional guidance is given in Section 9 of this document, for further reference.

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.

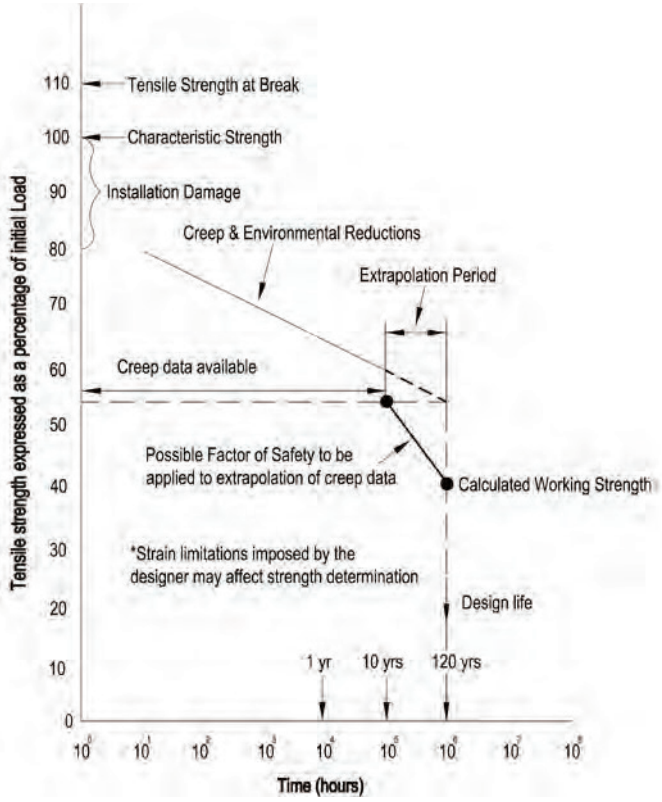


Fig. 1 Partial Factor Reductions to be considered in long term strength derivation

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 ACEGrid® geogrid shows a 71 % strength retention which equates to a partial factor of f_c= 1.41. The published value of f_c for a 120 year design life is 1.43.

ACEGrid®, 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 55% 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 geogrid.

Manufacturers of these products must be able to demonstrate creep testing of the manufactured product rather than simple creep testing of the yarn only.

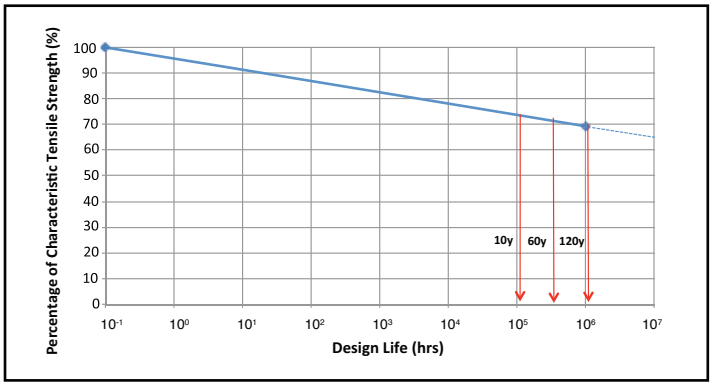


Fig. 2 Creep Rupture Curve
ACEGrid® Geogrid

4. Partial factor relating to installation damage, f_d

The magnitude of damage, f_d, imposed upon the ACEGrid® geogrid 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 ACEGrid® geogrid are derived from independent field and large scale laboratory tests. Values of f_d for ACEGrid® geogrid placed in varying 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 used. ACEGrid® geogrids 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 ACEGrid® geogrid range is 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.

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

ACEGrid® geogrids 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 ACEGrid® geogrid for consistency of manufacture, **f_{m11}, has a value of 1.0 for design lives up to 120 years** in accordance with BS 8006: 2010.

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

ACEGrid® geogrids 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 ACEGrid® geogrid is shown as a master curve in Fig.3. The graph shows, as the "y" ordinate, the strength of the ACEGrid® geogrid as a percentage of the characteristic short term tensile strength. Thus one master curve may be used to represent all ACEGrid® 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 reinforcement products.

Isochronous stress curves (refer to Fig. 4) 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 their data sheets which may lead to an over estimation of achievable geogrid strength for a long term design strain requirement.

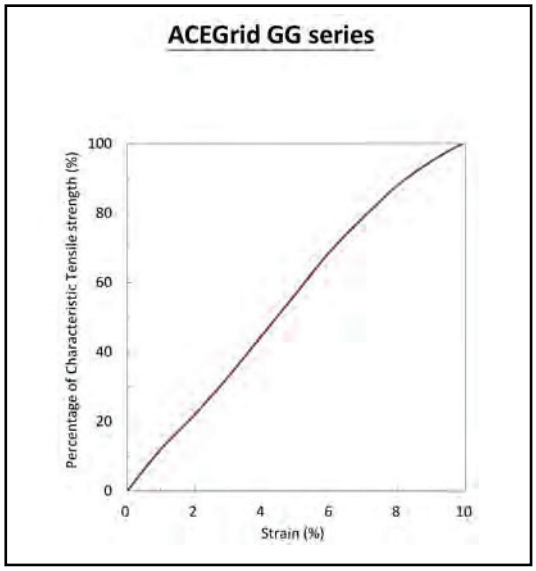


Fig. 3 Short term tensile strength-strain relationship for ACEGrid® Geogrid.

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

The long term tensile strength relationship to **strain** with the influence of **time dependency** for ACEGrid® geogrid is shown as a master curve in Fig.4. The graph shows, as the "y" ordinate, the strength of the ACEGrid® geogrid as a percentage of the characteristic tensile strength. The "x" axis is the strain component that is appropriate to long term loading conditions. This is theoretically any time greater than t=0 mins. 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 ACEGrid® geogrid 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 ACEGrid® grades by converting the percentage values into actual strength values for individual grades. Shown at Fig.5 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 65% of the characteristic short term tensile strength will satisfy this criteria.

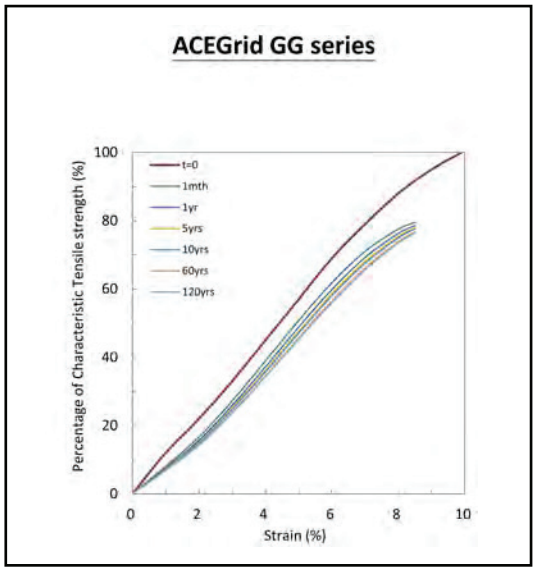


Fig. 4 Long term tensile strength-strain- time relationship for ACEGrid® Geogrid Isochronous curves.

9.0 Other Design Considerations and Benefits

9.1 Segmental Block Facing and ACEGrid®
Software is available for a range of proprietary facing options such as Keystone® and Anchor® Wall Systems. Contact GPIL.

9.2 RMS (NSW) and TMR (QLD) Approval and ACEGrid®
Full approval details may be downloaded from the RMS (ex RTA NSW) website. Specifications RMS R57, RMS R67, TMR MRTS06, and TMR MRTS100 apply.

9.3 BBA Certification for Applications of Slopes and Basal Reinforcement
Full documentation available for design to BBA certification. Contact GPIL.

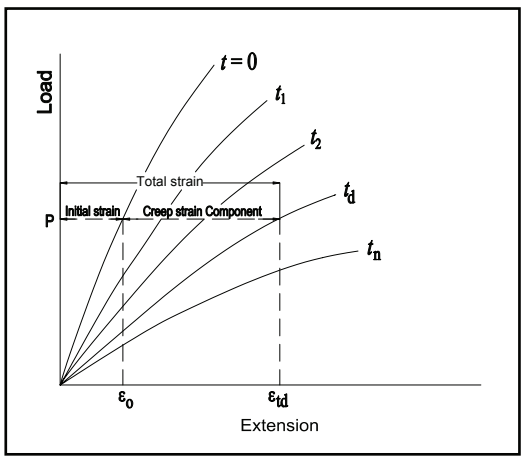


Fig. 5 Method of determining the various components of strain.

PROPERTIES OF ACEGrid® HIGH PERFORMANCE UNIAXIAL GEOGRID

PROPERTY		UNITS	GG40	GG60	GG80	GG100	GG120	GG150	GG200
MECHANICAL PROPERTIES									
Mean ultimate tensile strength ISO 10319	MD	kN/m	45	70	90	110	130	165	219
Characteristic ultimate tensile strength ISO 10319	MD	kN/m	42	65	84	106	121	157	206
Strain at short term strength ISO 10319	MD	%	10	10	10	10	10	10	10
Partial factor - creep rupture - f_c									
at 10 years design life			1.37	1.37	1.37	1.37	1.37	1.37	1.37
at 60 years design life			1.41	1.41	1.41	1.41	1.41	1.41	1.41
at 120 years design life			1.43	1.43	1.43	1.43	1.43	1.43	1.43
Creep limited strength									
at 10 years design life	MD	kN/m	31	47	61	77	88	115	150
at 60 years design life	MD	kN/m	30	46	60	75	86	111	146
at 120 years design life	MD	kN/m	29	45	59	74	85	110	144
Partial factor - construction damage - f_d in course gravel less than 50mm			1.1	1.1	1.1	1.1	1.1	1.1	1.05
Partial factor - environmental effects in soil environment 2 < soil pH < 10 - f_e									
not exceeding 10 years design life			1.01	1.01	1.01	1.01	1.01	1.01	1.01
at 60 years design life			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
Long term design strengths - t_d in coarse gravel less than 50mm									
at 10 years design life	MD	kN/m	28	43	56	70	80	104	143
at 60 years design life	MD	kN/m	26	41	53	66	76	98	135
at 120 years design life	MD	kN/m	25	39	51	64	73	95	131
Nominal roll width		m	4	4	4	4	4	4	4
Nominal roll length		m	50	50	50	50	50	50	50
Nominal roll mass		kg	55	60	65	80	95	108	140

NOTE:
1. The characteristic short term strength is the statistical 95% confidence limit.
2. All creep testing has been carried out at 20^0 C.
3. Roll widths to 5m are available.
4. The cross direction (C.D.) strength is 30kN/m
5. Long term design strength are characteristic values.

Long term design strength is determined by compounding the reduction factors for creep, installation, and environmental effects. ACEGrid® is made from polyester yarn with high molecular weight, Mn > 30,000 and a Carboxyl End Group, CEG of <14 mmol/kg. ACEGrid® is resistant to all naturally occurring 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.

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