THE NEED FOR GEOSYNTHETIC STANDARDS AND GENERIC SPECIFICATIONS

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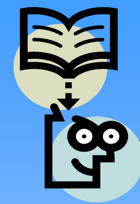
The Specification



What do we mean by a Geosynthetics Specification?

Is it a menu of tests which give a list property values?

Is it a time defined performance requirement ?

Do the test methods or performance criteria in the specification meet your understanding of the needs of the particular application or project?

If the specification is lacking in detail or demand it is the responsibility of both the user and the supplier to bring this to the attention of the specifier

If a "Standard Specification" is being cited does it address and satisfy the functions and requirements that you consider the geosynthetic must fulfil on a particular project?

Standard Specifications are just general guides and often must be modified and made project specific

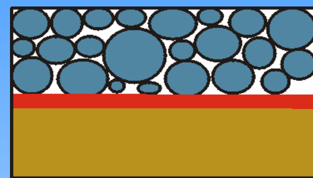
Specifications should primarily be based on function, the environment of the application together with with regard to the material of manufacture.

In Europe the "Requirement Document" is focuses on the application e.g. Roads, Railways, and Canals etc however within the document the property requirements are functionally lead.

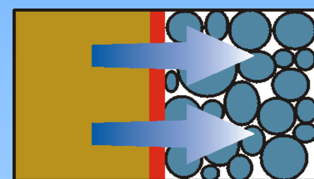
In North America the specifications are functional but strongly linked to the product structure and material content.

The mail functions of geosynthetics are:

Separation

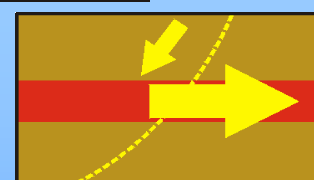


Filtration

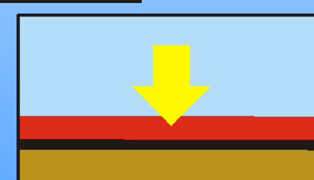


Drainage

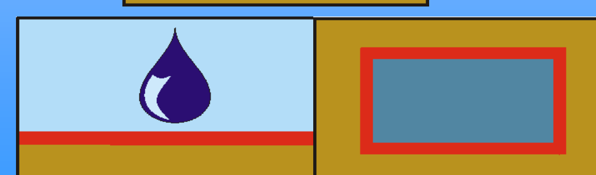
Reinforcing



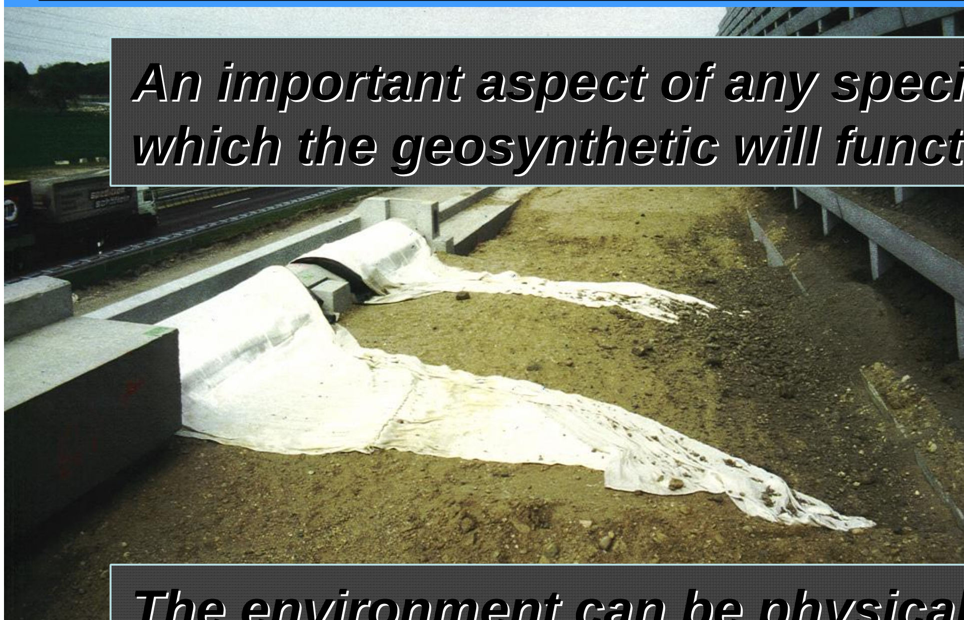
Cushioning

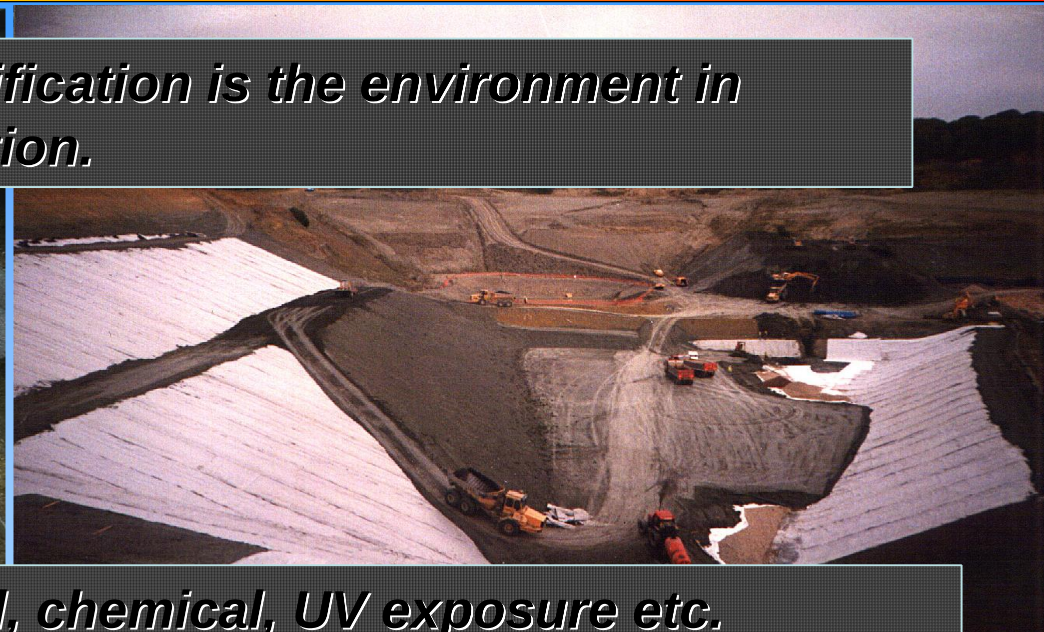


Barriers and containment



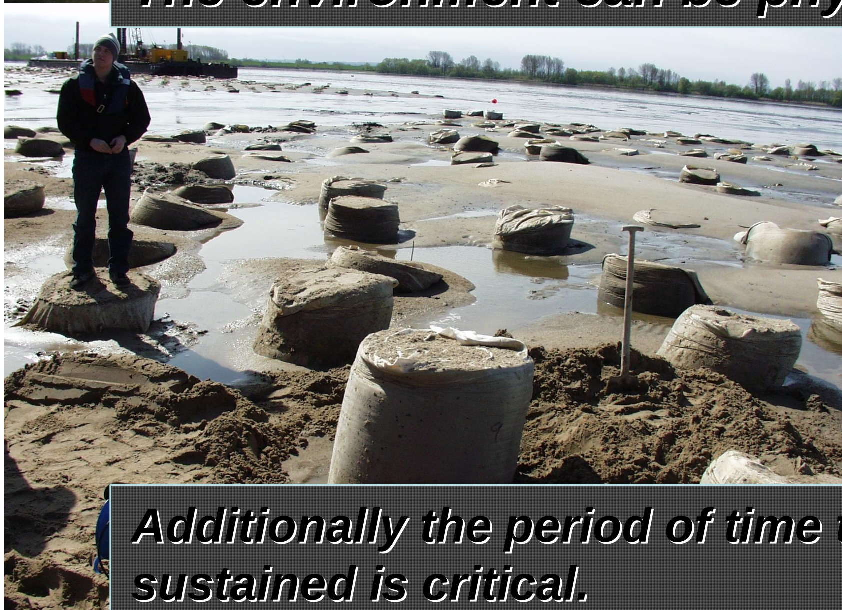
Many applications will require more than one function, e.g. separation and filtration





An important aspect of any specification is the environment in which the geosynthetic will function.

The environment can be physical, chemical, UV exposure etc.



Additionally the period of time that the particular function must be sustained is critical.

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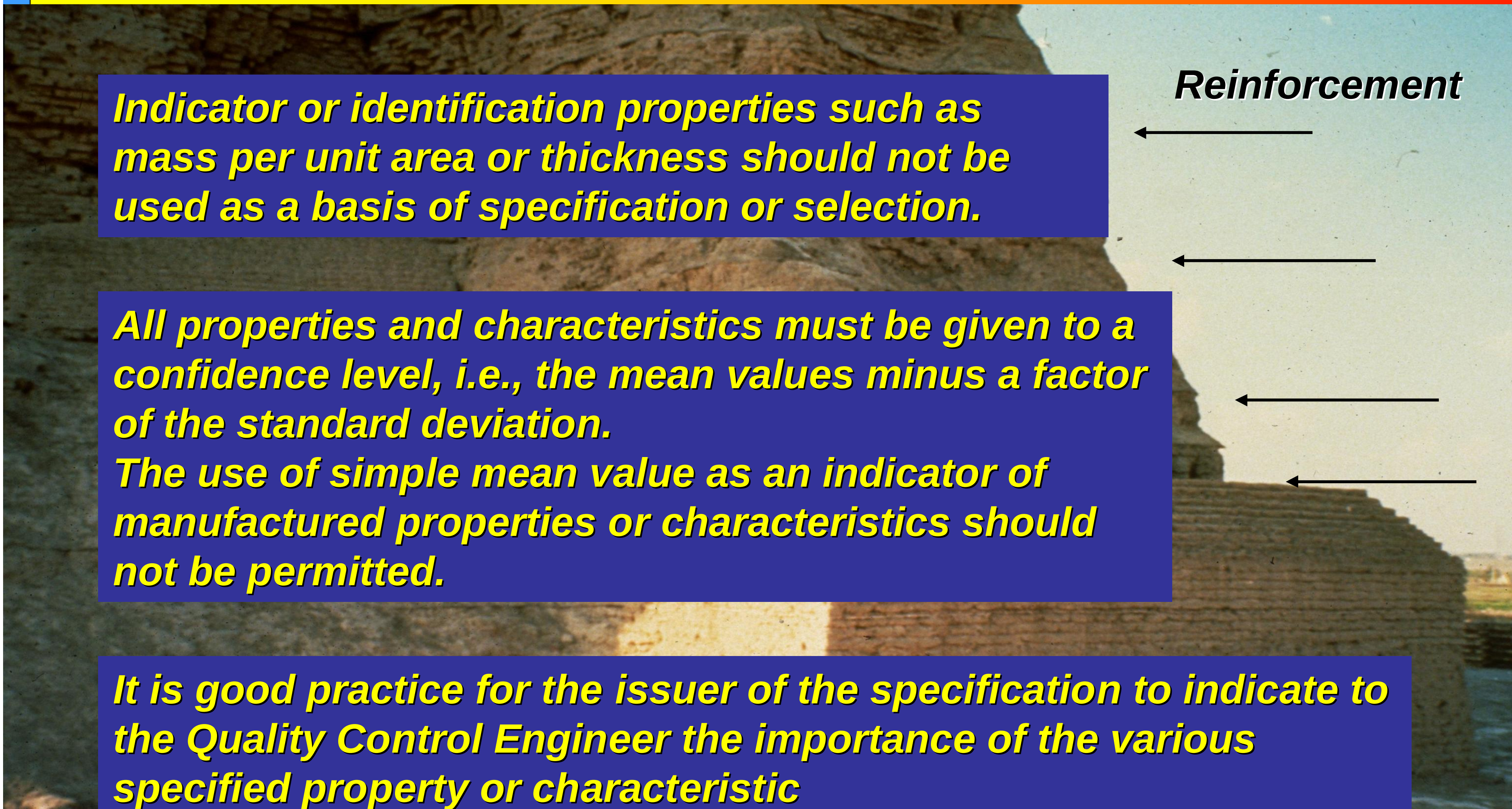

Indicator or identification properties such as mass per unit area or thickness should not be used as a basis of specification or selection.

All properties and characteristics must be given to a confidence level, i.e., the mean values minus a factor of the standard deviation.
The use of simple mean value as an indicator of manufactured properties or characteristics should not be permitted.

It is good practice for the issuer of the specification to indicate to the Quality Control Engineer the importance of the various specified property or characteristic

Ziggurat Iraq 2000 BC

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Geosynthetic standards

There is excellent international and integrated cooperation and consensus on geosynthetic testing standards and procedures exemplifies by the ISO Technical Committee 221.

The host of geosynthetic test methods and assessment procedures for the Engineer to select from. The key to assembling a proficient specification is understanding the function and demands that the geosynthetic has to fulfil

The international nature of geosynthetic commerce has made the propagation of proprietary specification widespread; this has positive and negative aspects. Frequently international companies offer specifications to Engineers which do not mention the product name, while such proprietary specifications are technically competent they are selective in properties and characteristics given as well as being anticompetitive and proscriptive

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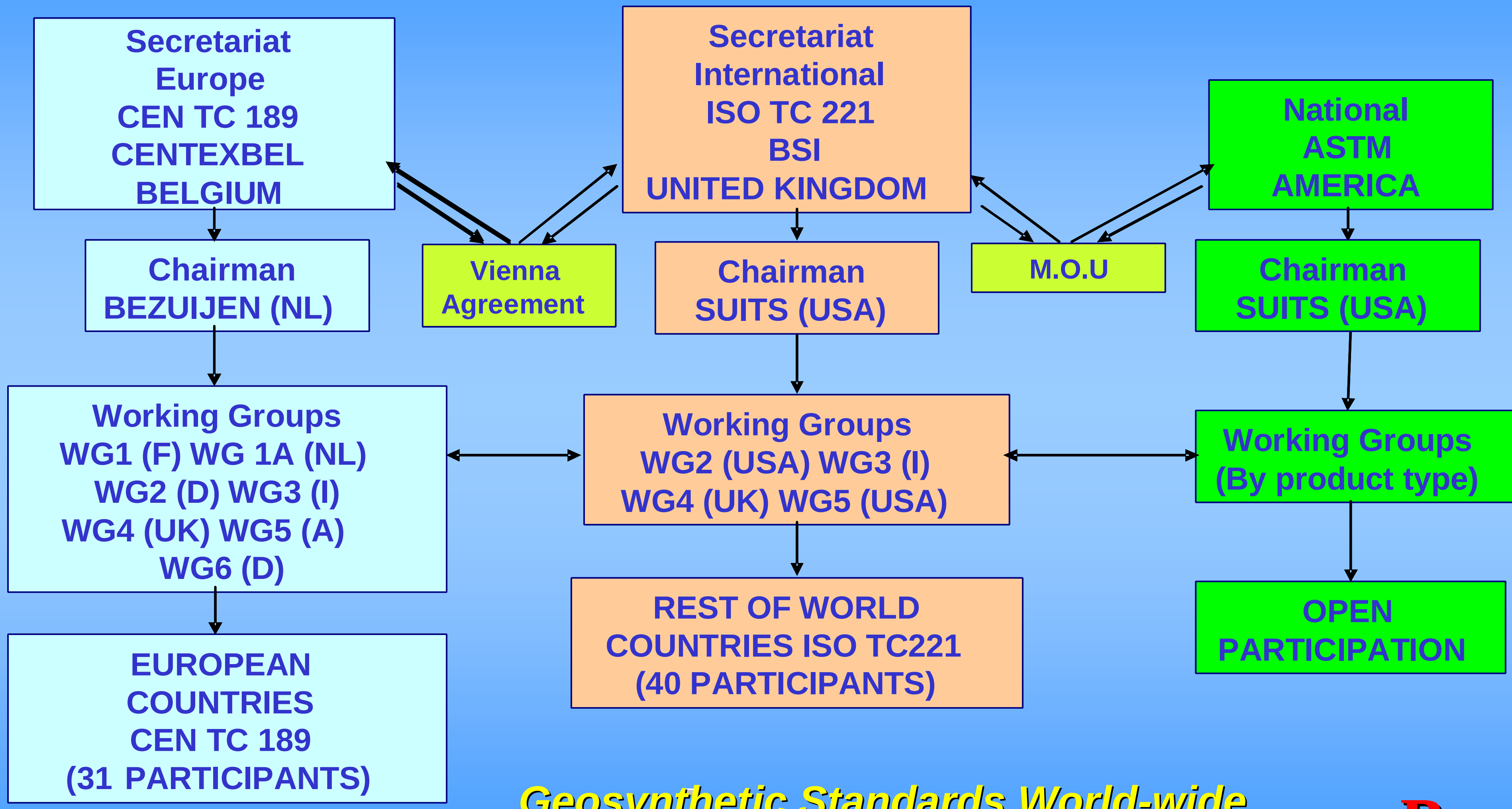
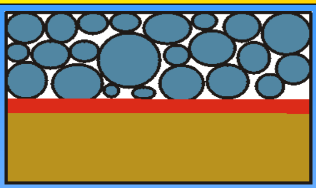


Geosynthetic Standards World-wide

Separation



Separation is the dominant function of geosynthetics when measured in product sold or area covered.

While many of the applications in which geosynthetic separation is require may be low risk, the total economic impact of poor performance is considerable.

There are extensive selections of separation specification available; these vary in applicability and relevance e.g. GRI, IGS, NGS etc

In many jurisdictions compliance with the "National Specification" is an obligation; nevertheless this adherence should not lead to complacency or lack of rigor in assessing the functional requirements and specification for a particular project.

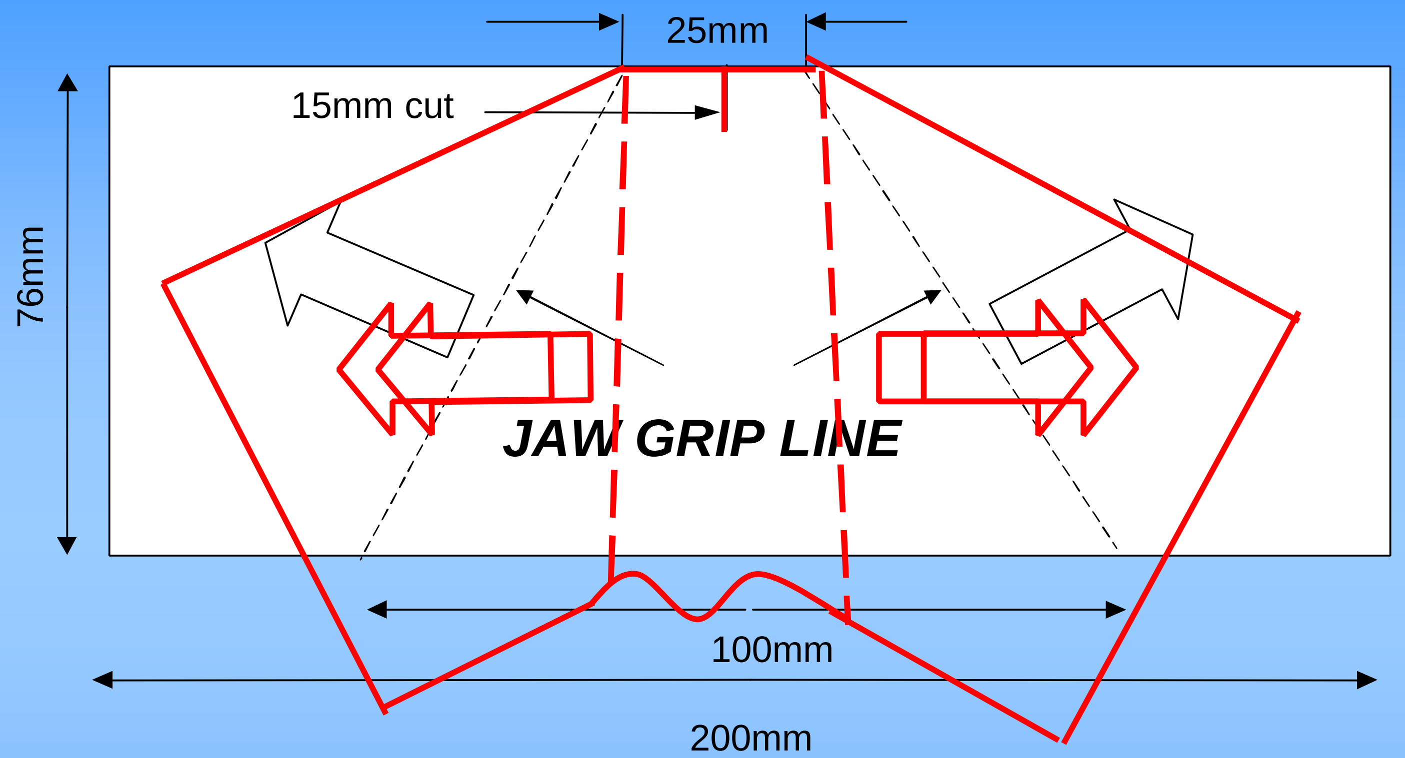
Separation

The main reason for the failure of geosynthetic separation is puncture and tears together with poor soil retention. Much of the damage to a separator occurs during installation.

Unidirectional tensile strength is a poor indication of separation performance; slow tear propagation tests such as trapezoidal tear are irrelevant and misleading

Bidirectional puncture, CBR, is a good indicator of separation performance.
Dynamic puncture, Drop Cone, is an excellent test for assessing the resistance to installation damage together with tear initiation and tear propagation.

Pore size can be critical in dynamic loading (railways) and with frost susceptible soils.
Water flow is seldom a problem in soil aggregate separation



TRAPEZOIDAL TEAR

ASTM D4533-91

GAUGE LENGTH 25 mm

SPEED 300mm/min

An irrelevant and misleading geosynthetic test due to the slow speed of tear propagation

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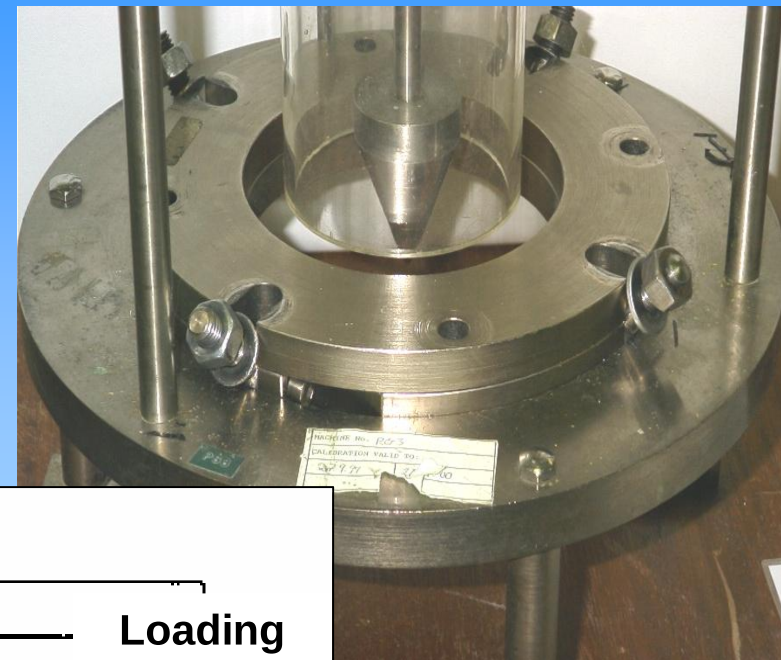
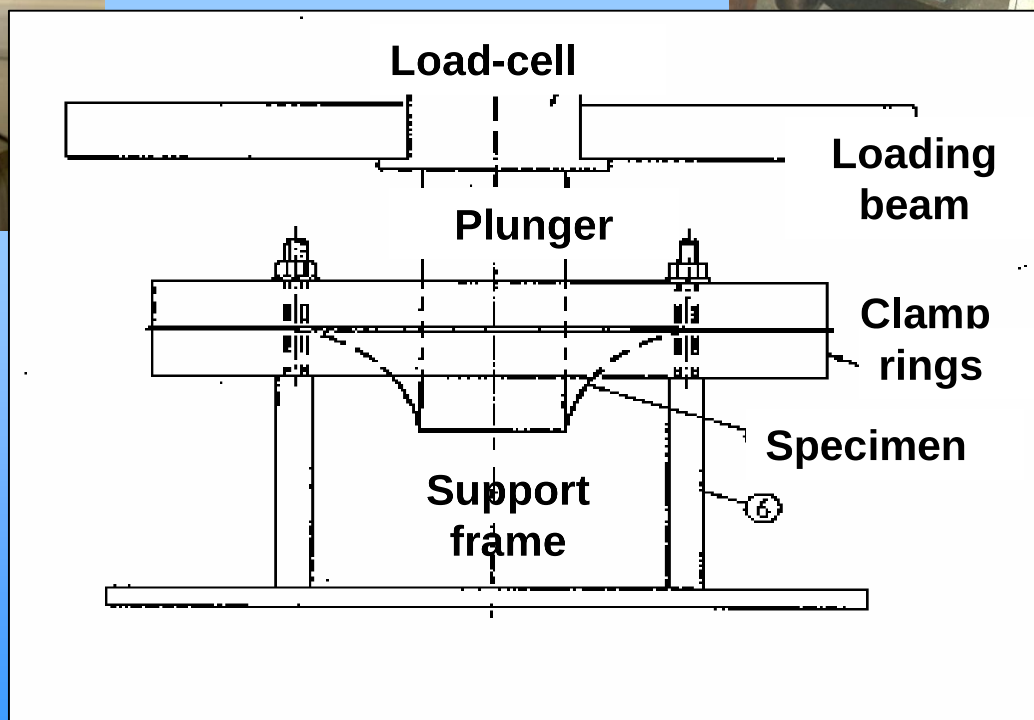
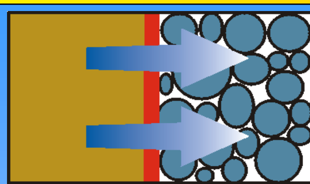


EN ISO 12236 CBR (Puncture Test)



EN ISO 13433 Drop Cone Test

Filtration



Filtration is often the forgotten child of geosynthetics and while not large in commercial importance the consequence of poor or inadequate performance can be catastrophic.

The environment in which the filter will function plays a vital role in the content of the specification.
Simple unidirectional low gradient flow in a land drain will allow a much broader specification than would a dynamic reversing flow in a sea wall.

The risk factor and consequence of failure also influence the specification, the hydraulic environment may be similar but few would suggest that the land drain and the toe drain of a dam should be considered with the same diligence

The CBR and Cone drop are good test to use in specifying the physical properties of a filter geosynthetic.

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Filtration

The pore size should generally be defined as O90 i.e. the size of opening which is equal to the particle size d90 of the granular material that has passed through the geosynthetic.

The pore size should be defined by a wet sieving test EN ISO 12956 other more experimental procedures are under development, bubble point, mercury intrusion but these should only be used as in conjunction with wet sieving.

Dry sieving test should not be used as the values produced have been shown to be inaccurate and misleading.

There are several “rules” and formulae for matching the soil grading to the pore size of the geosynthetic. The accuracy or dependability of these rules can be judged by the considerable range of values that emerge from these recommendations (however most seem to work).

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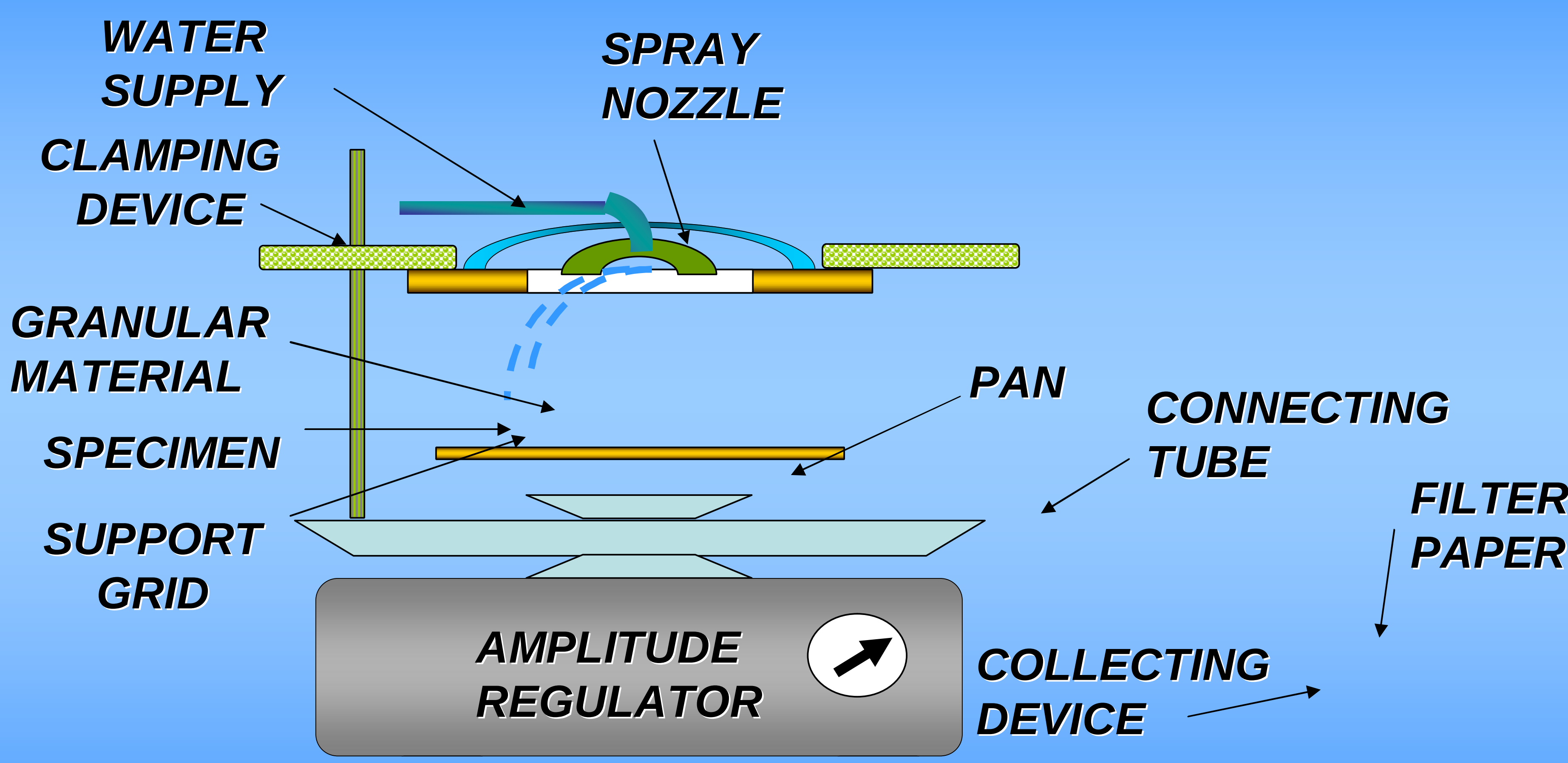
Filtration

In general for unidirectional flow keep the O90 below the d90 and above the d50 of the soil to be filtered.
Due to the likely establishment of a filter zone in the soil adjacent to the geosynthetic the tolerance on the compatibility of O90 to d90 is large.

For reversing and turbulent flow keep the O90 below the d60 and above the d30 of the soil to be filtered, however the tolerance between the pore size of the geosynthetic and the soil is small.

If the project is large or of a critical nature or if the soil has fine and uniformly graded (dredged soil) then a reversing flow test type German Federal Waterway Engineering and Research Institute (BAW) Mechanical filtration stability for very fine grained soils (reversing turbulent flow method) should be carried out.

EN ISO 12956 (WET SIEVING)

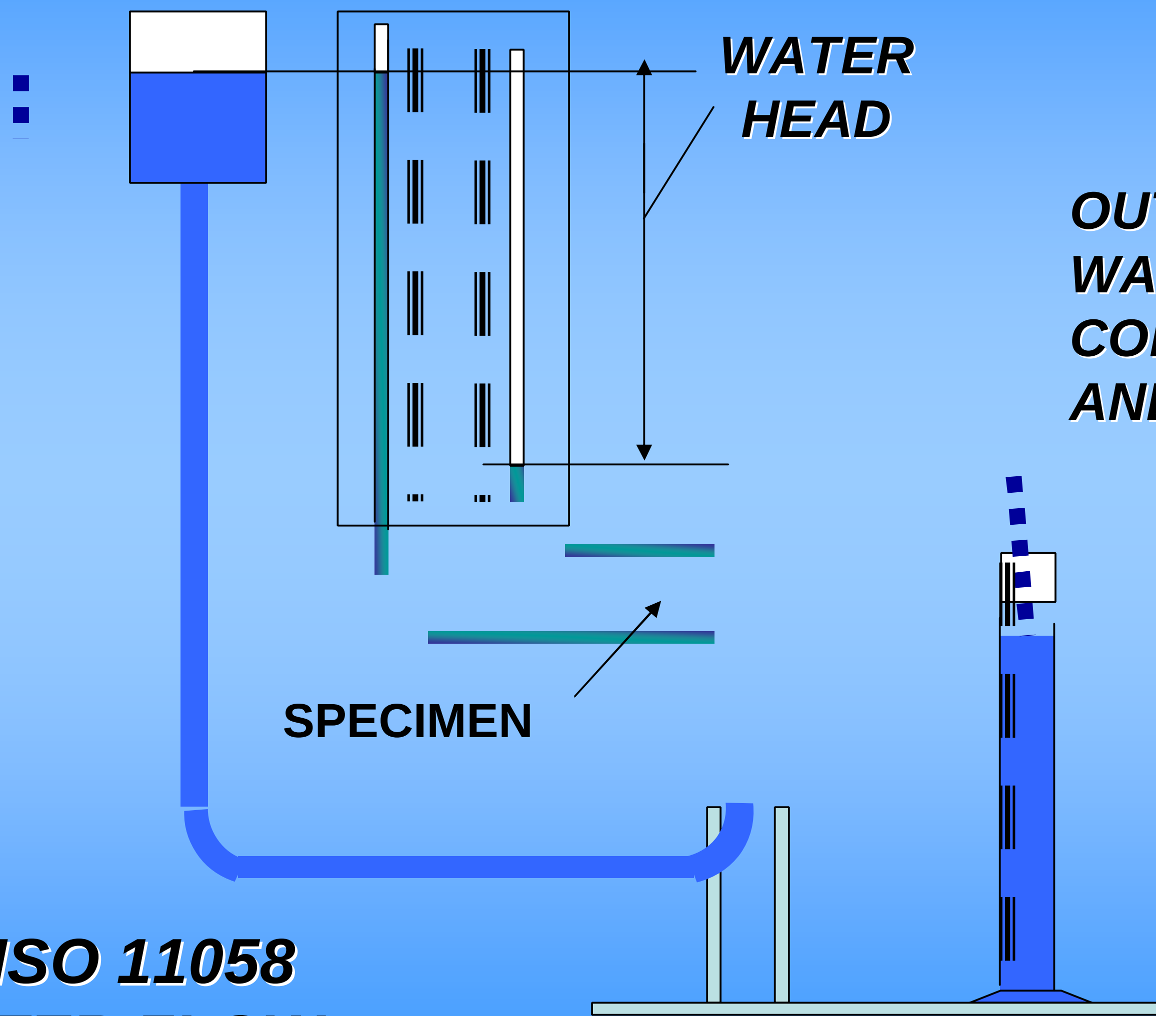


Filtration

The water flow through filter geosynthetics is generally more than sufficient however the conventional water flow test EN ISO 11058 does tend to overestimate the water flow particularly with needle punched structures.
A more realistic appraisal of the water flow can be obtained by testing to the draft ISO Determination of water permeability normal to their plane under load. This test procedure tests the water flow to confining pressure of 200 kPa which can be of interest in dam filtration.

Geosynthetic filters can be clogged by bacterial growth, the inclusion of graded granular layers in conjunction with the geosynthetic can mitigate this problem however if significant bacterial or mineral clogging is anticipated than the use of a geosynthetic filter may be inappropriate.

INFLOW OF WATER



OUTFLOW OF
WATER TO BE
COLLECTED
AND TIMED

EN ISO 11058
WATER FLOW

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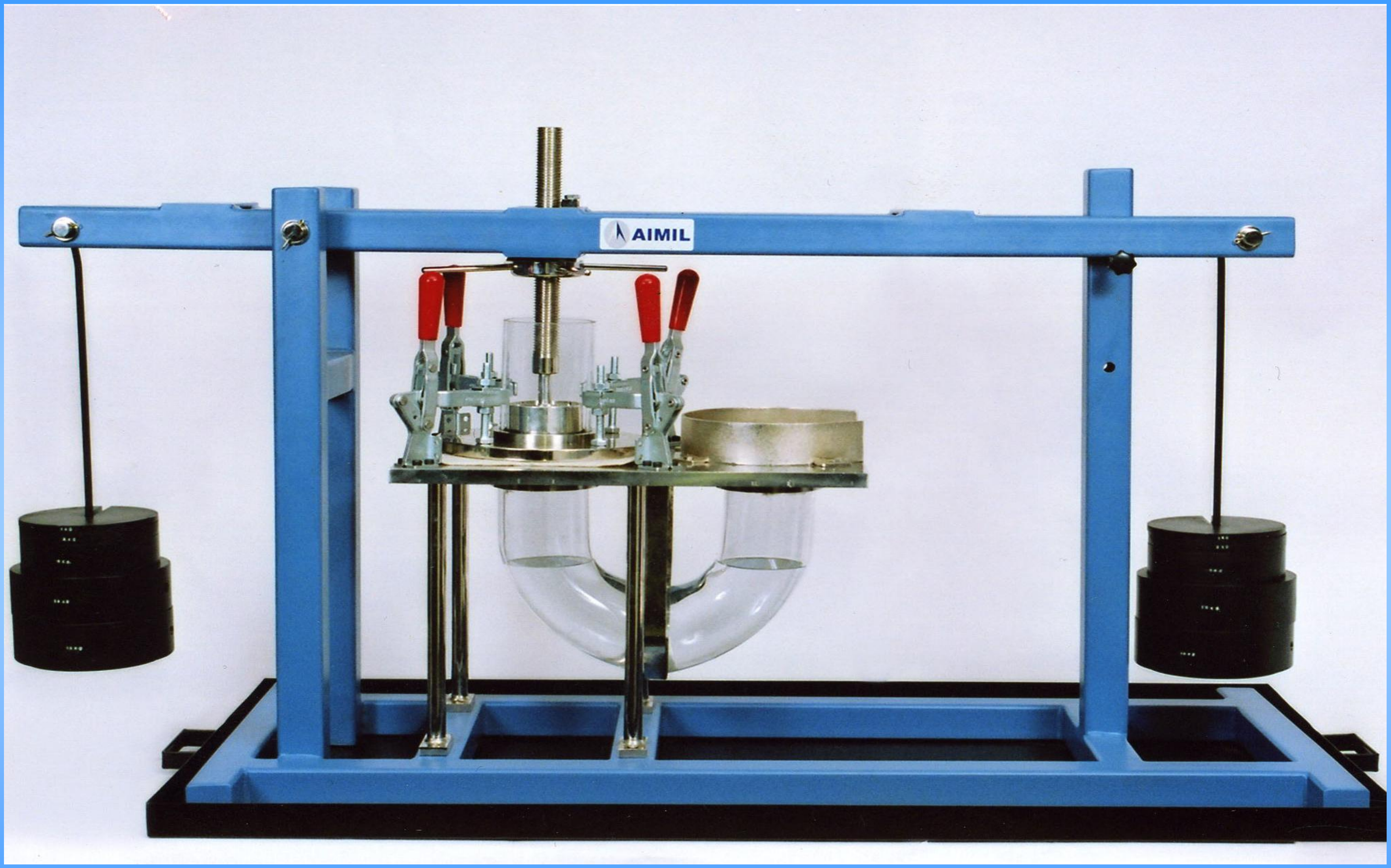

Draft ISO WI1026A Determination of water permeability normal to their plane under load.

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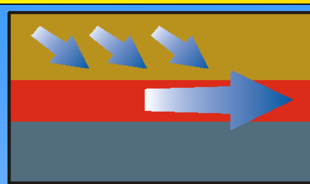
Drainage



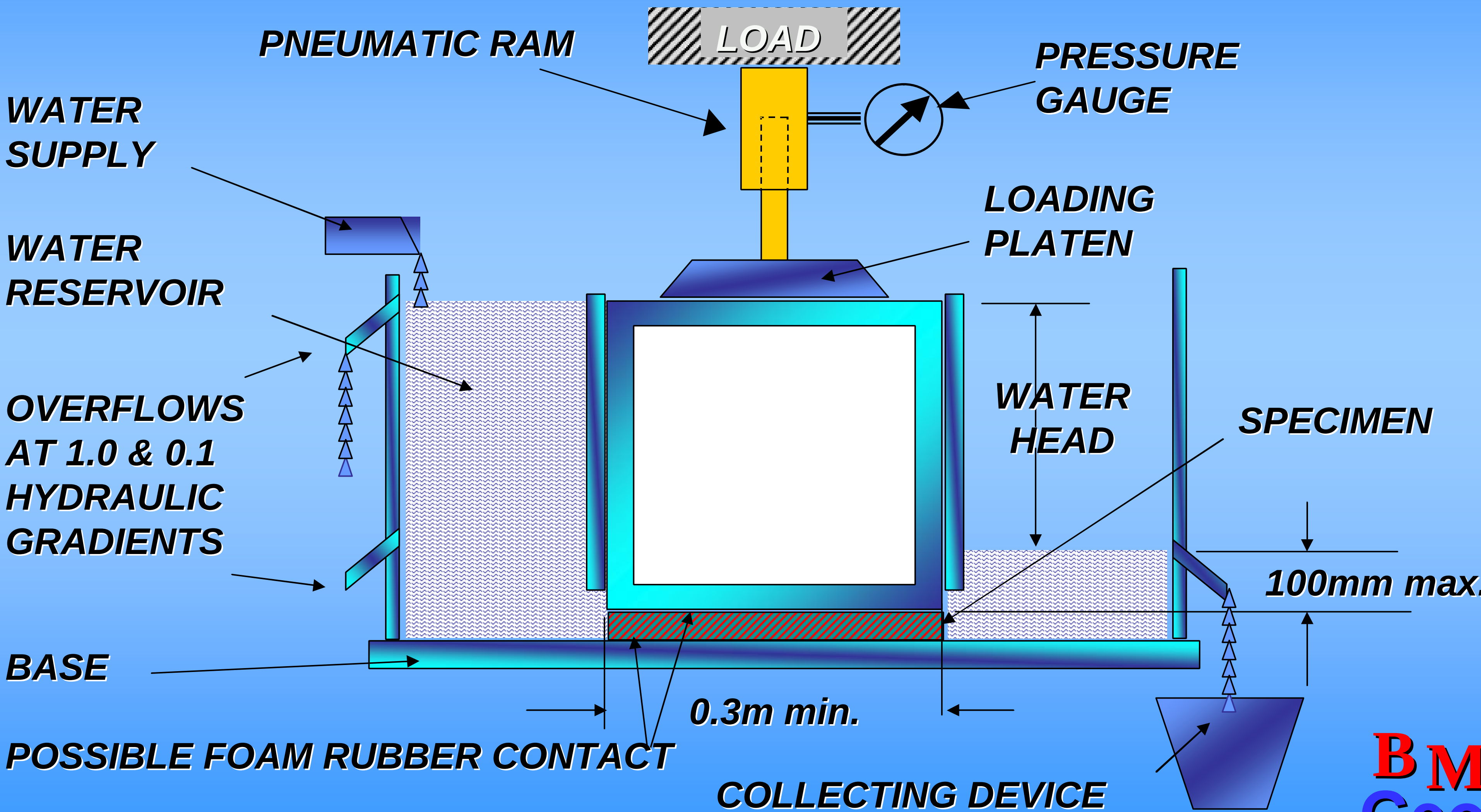
Drainage geosynthetics in the form of filter-core composites are being increasingly used. These are being utilized to evacuate both fluids and gasses.

The specification of the cover filter is addressed previously however the peel strength of this filter and the aqueous stability of the filter adhesion to the core should be tested by pre-soaking prior to the peel test.

The primary test for the drainage is the EN ISO 12958 - Determination of water flow capacity in their plane however this test must be done in conjunction with EN13432 - Determination of compressive creep properties, this test procedure must be carried out in the compression and shear mode.

When specifying the testing parameters for EN ISO 12958 it is important to select a hydraulic gradient appropriate to the actual application.

EN ISO 12958 IN PLANE WATER FLOW (TRANSMISSIVITY)



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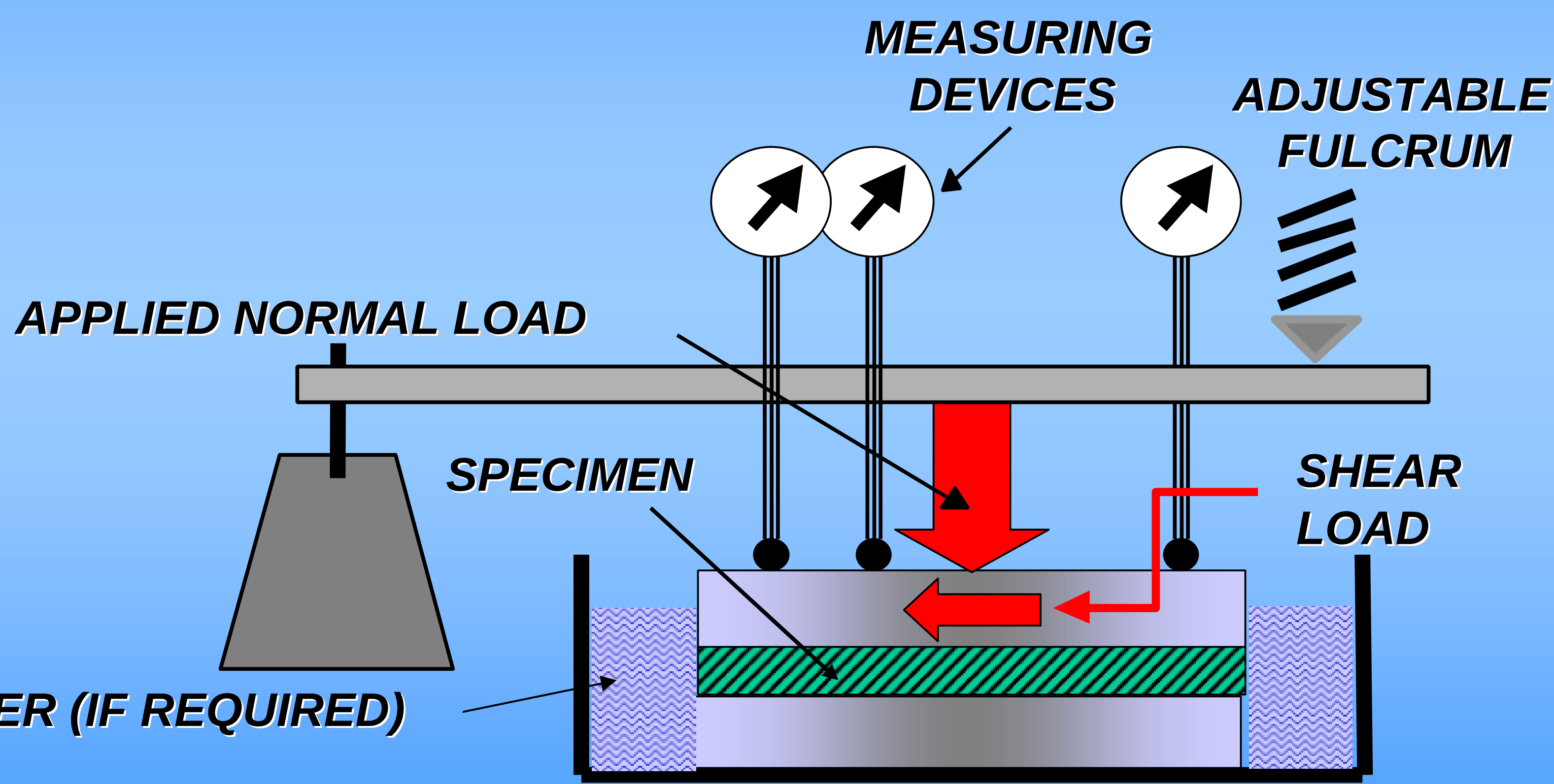
EN ISO 13432
DETERMINATION OF COMPRESSIVE CREEP PROPERTIES



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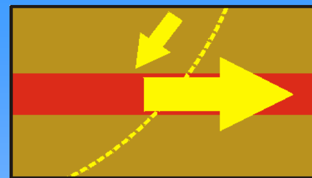
Reinforcing



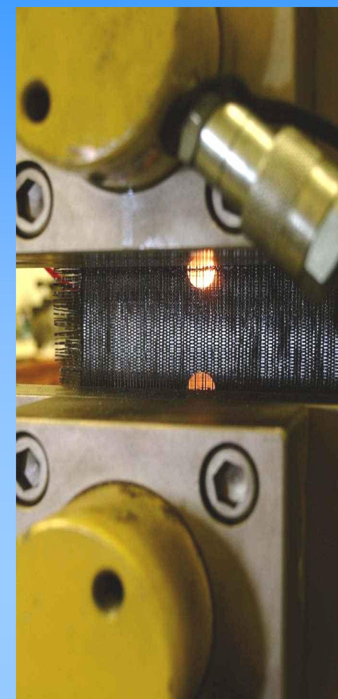
Reinforcing specifications are often the most markedly proprietary and are dominated by unidirectional strength

The specification requirements of a reinforcing geosynthetic can be divided into Serviceability and Limit State condition.

Serviceability

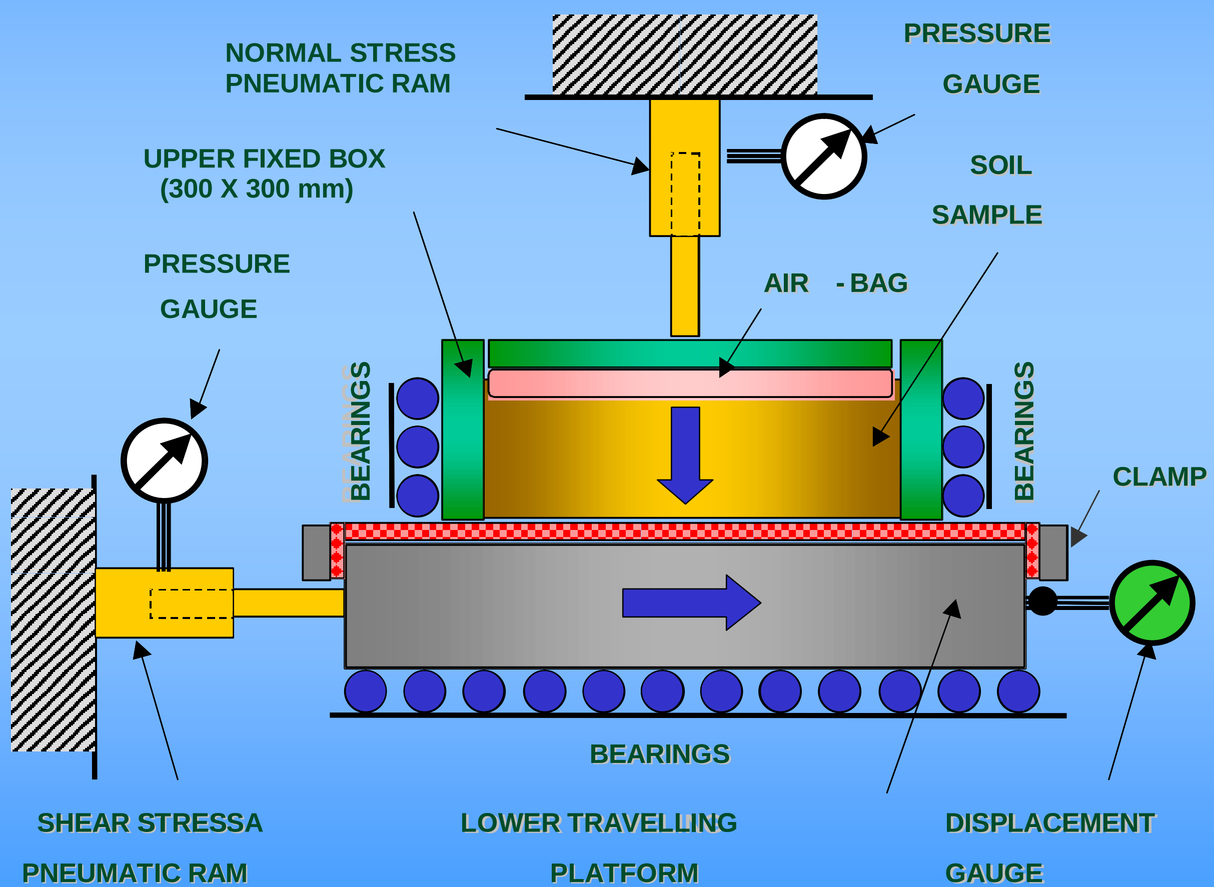
The "in use" condition of most reinforcing geosynthetics do not exceed 3% elongation. The unidirectional tensile strength at 2.5% is therefore important and this must be determined without pretension or "capstan massage"

The frictional properties according to EN ISO 12957-1 should be assed with representative aggregate as well as the geosynthetic face to geosynthetic face friction.



EN ISO 10319
WIDE WIDTH TENSILE TEST

ISO 12957-1 DETERMINATION OF FRICTION CHARACTERISTICS – PART 1: DIRECT SHEAR TEST



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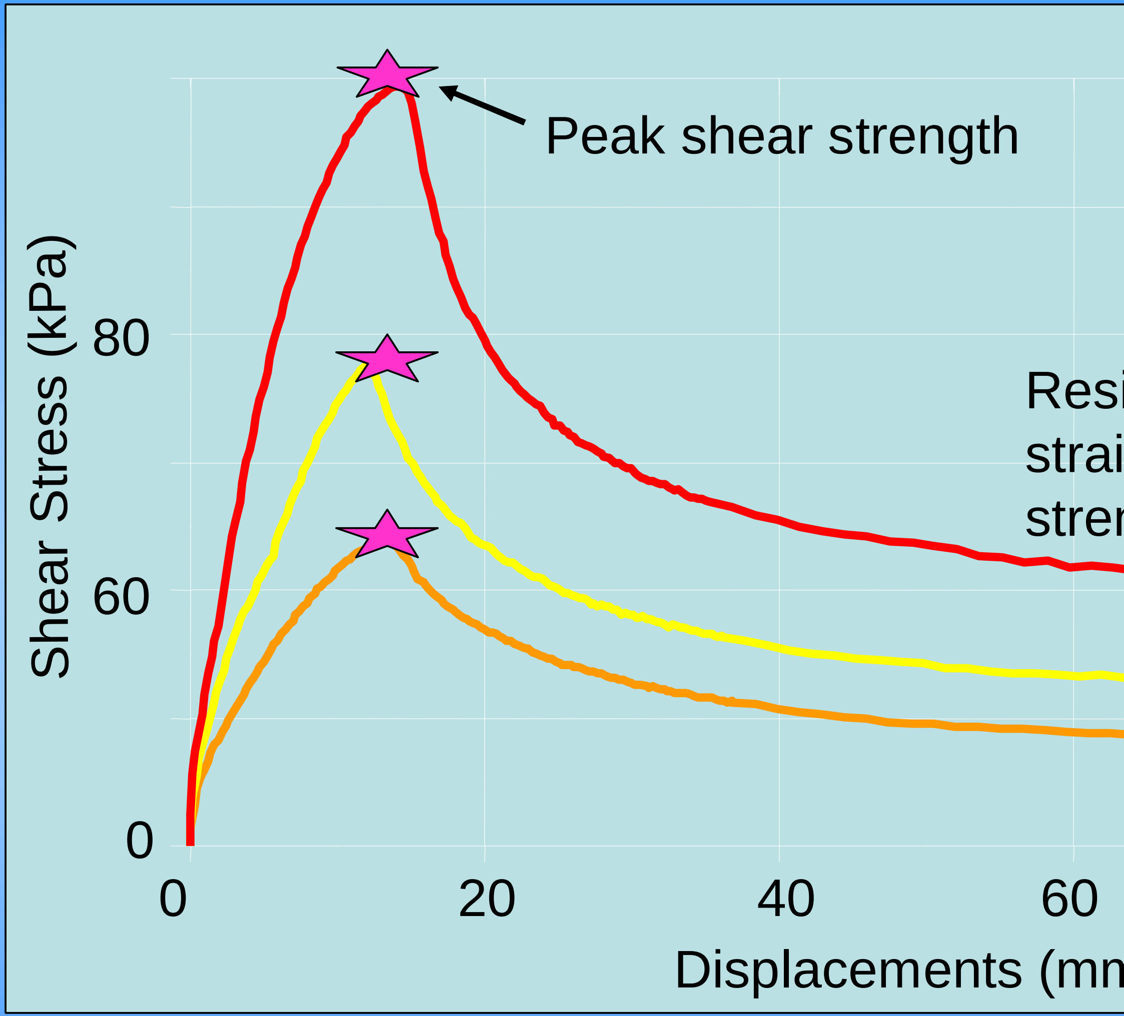

After the peak strength is achieved there is a rapid reduction in shear strength to a residual level.

Measurement of Peak and Residual Shear Strength

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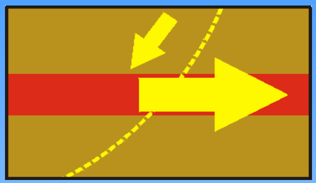
The specification for a geosynthetic reinforcement should ask for the reduction factors used.



Installation damage

Creep deformation

Chemical degradation

Biological degradation

If seams or connections are to be employed then the allowable strength shall per unit width or connection point shall be given.

The specification should give the required working load at a specified time, (i.e. 75kN at 100 years)

In addition the specification should require the stress rupture plot for the specified lifetime of the structure on a linear strength to log time base.

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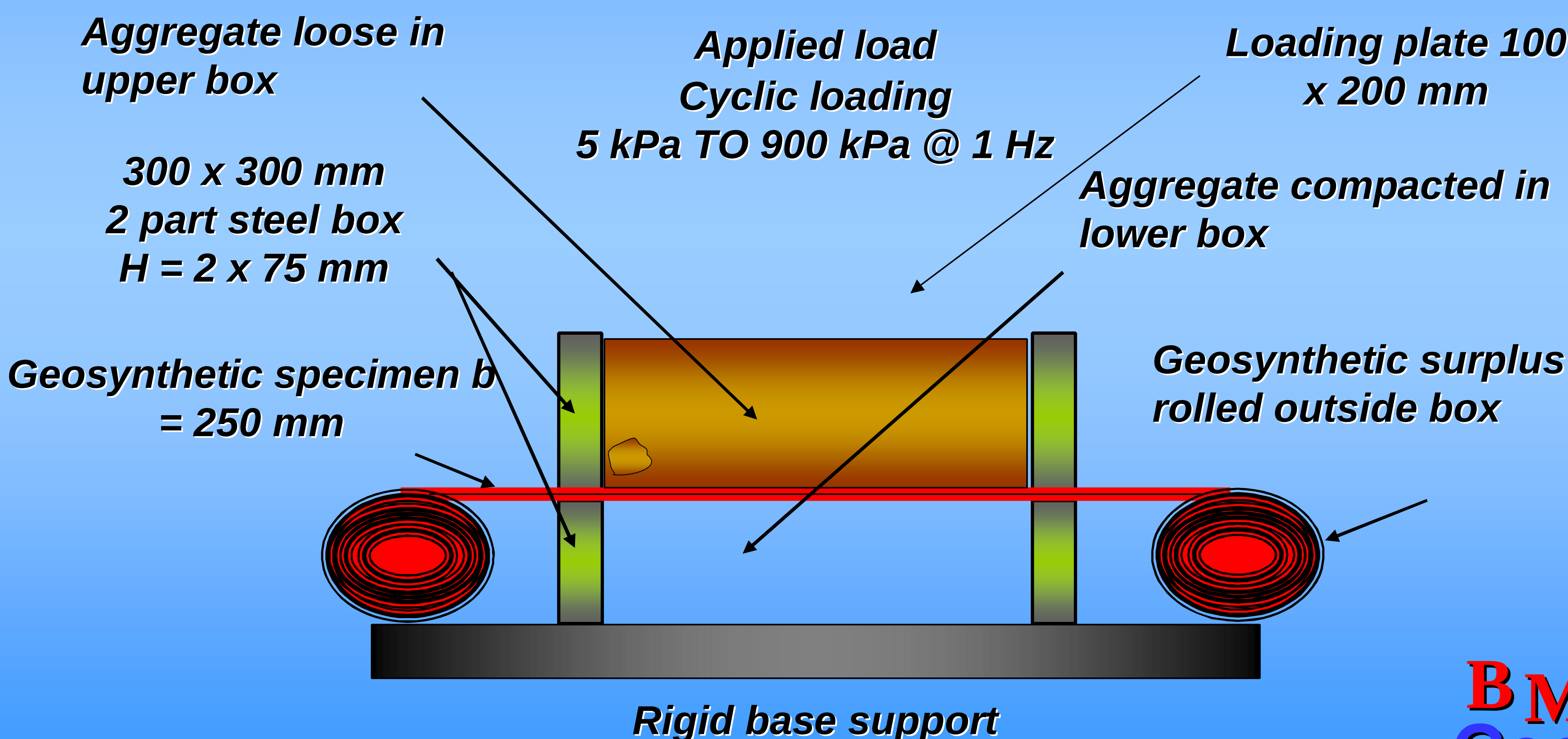
DD ENV ISO 10722-1 Procedure for simulating damage during installation
Part 1: Installation in granular materials



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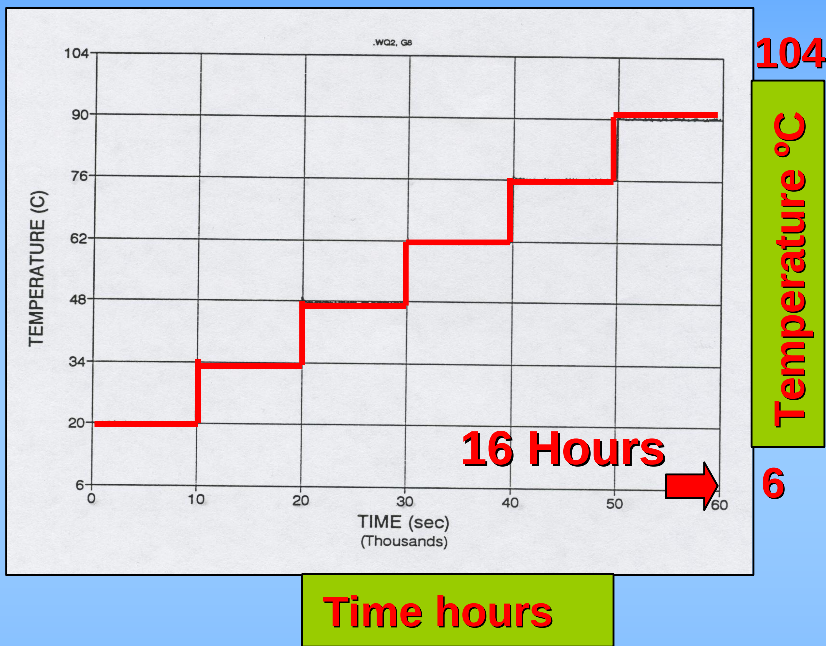
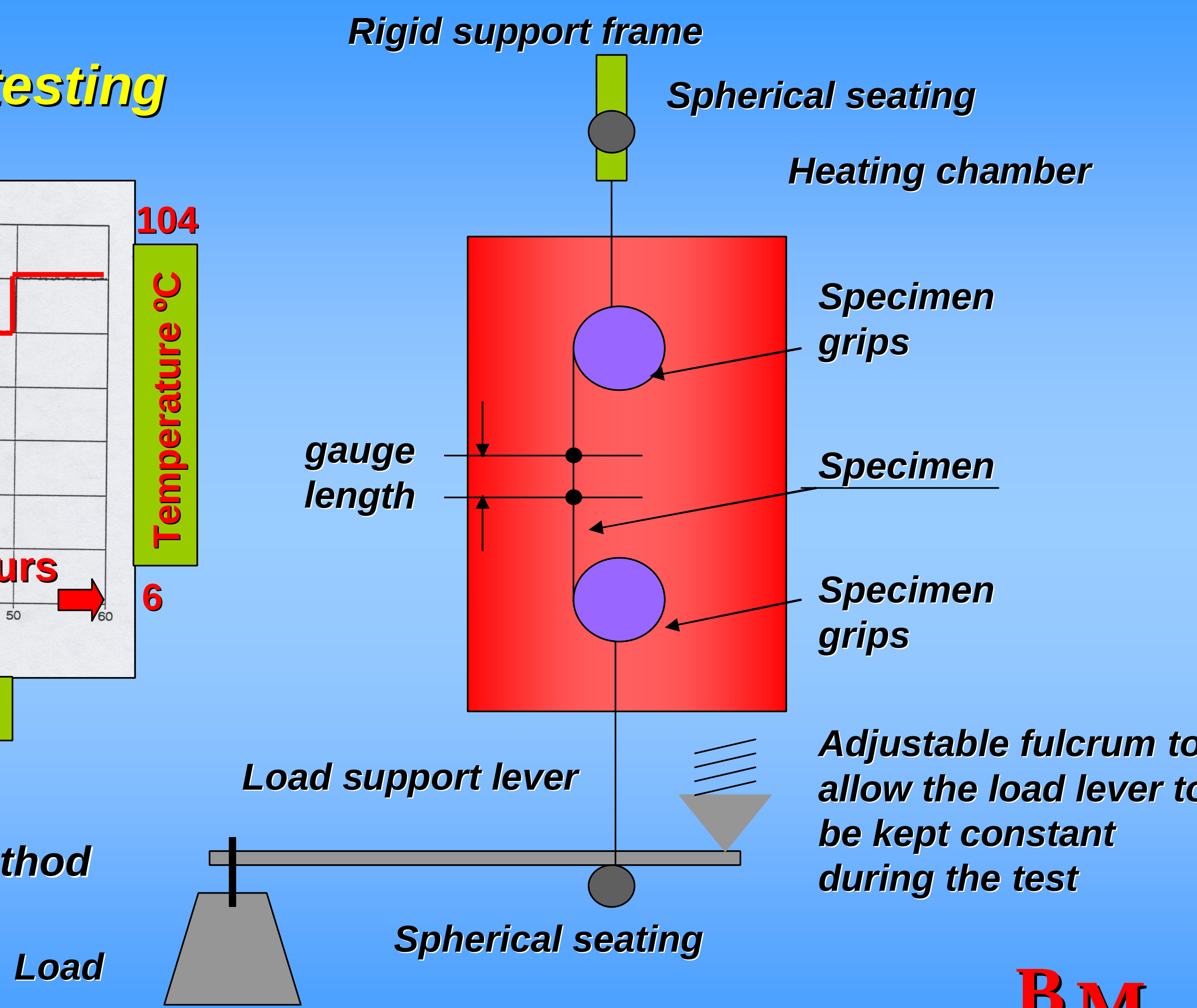
Accelerated creep testing



SIM

Stepped Isothermal Method



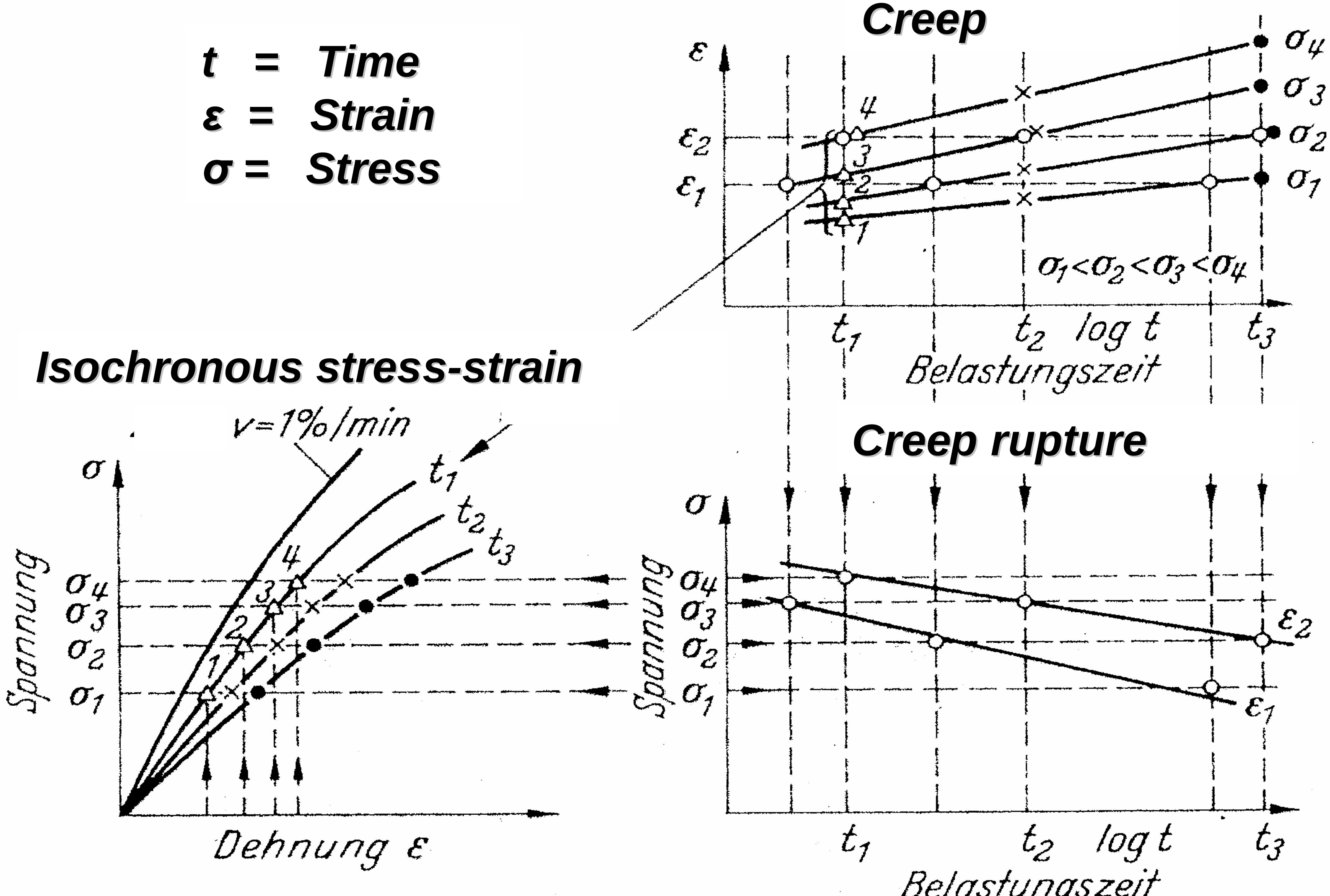
Relationship between creep, creep rupture and isochronous stress-strain

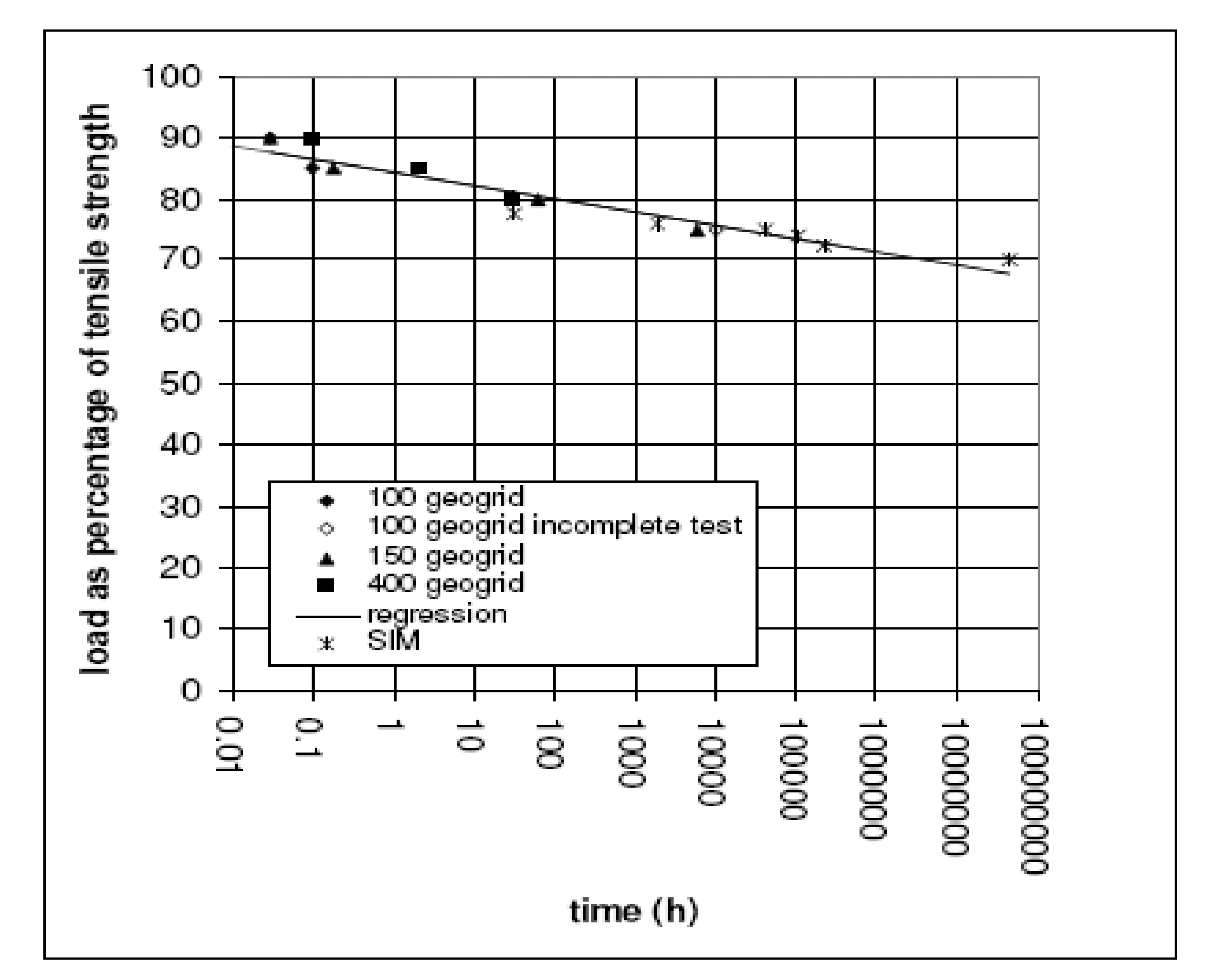
t = Time
ε = Strain
σ = Stress

Creep

Isochronous stress-strain

Creep rupture





Creep-rupture diagram including SIM tests

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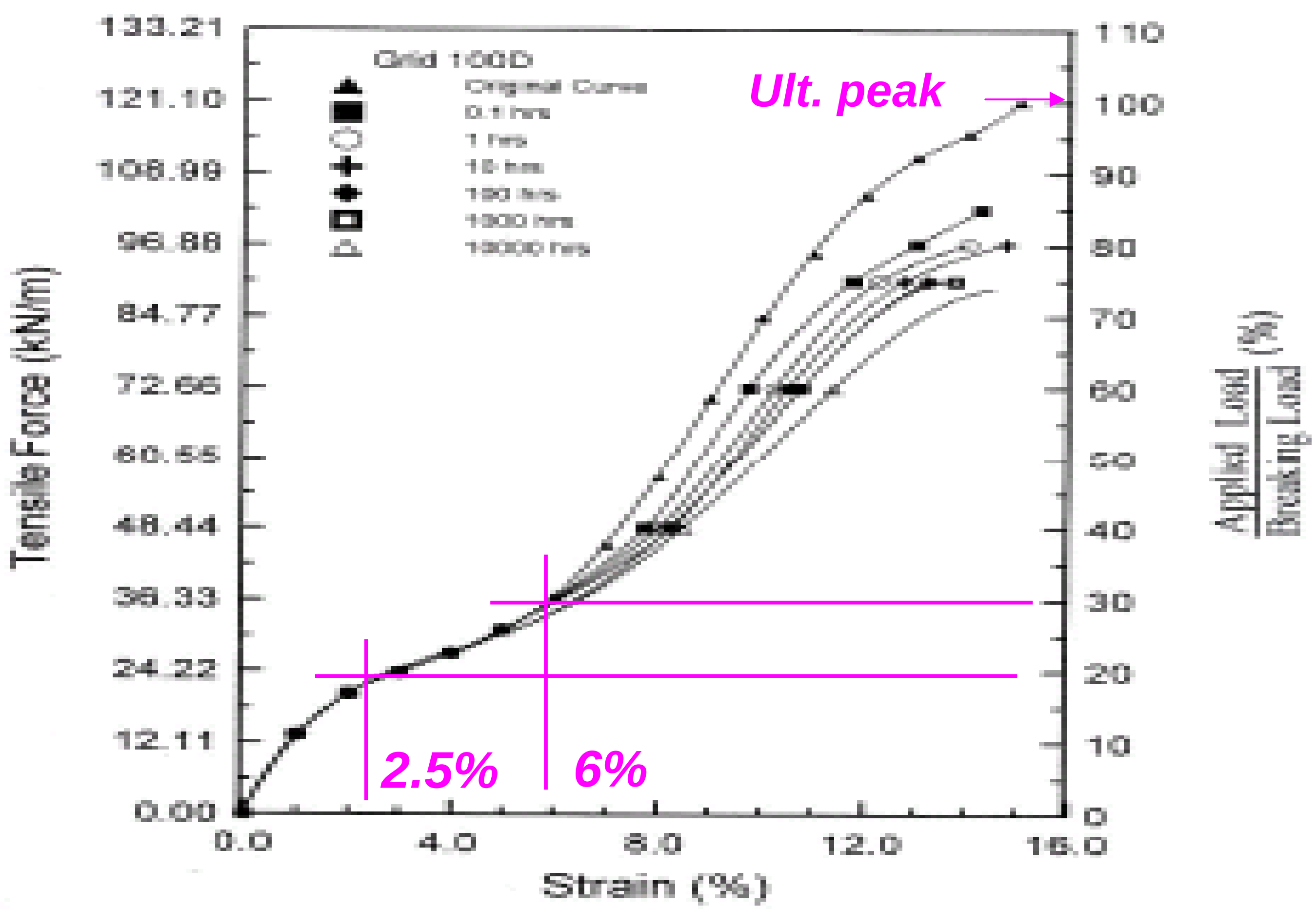
Reinforcing - Limit State



isochronous creep curves

A realistic factor of safety may be 1.2 but only if the available peak strength resistance from the geosynthetic is compatible with the peak soil resistance.

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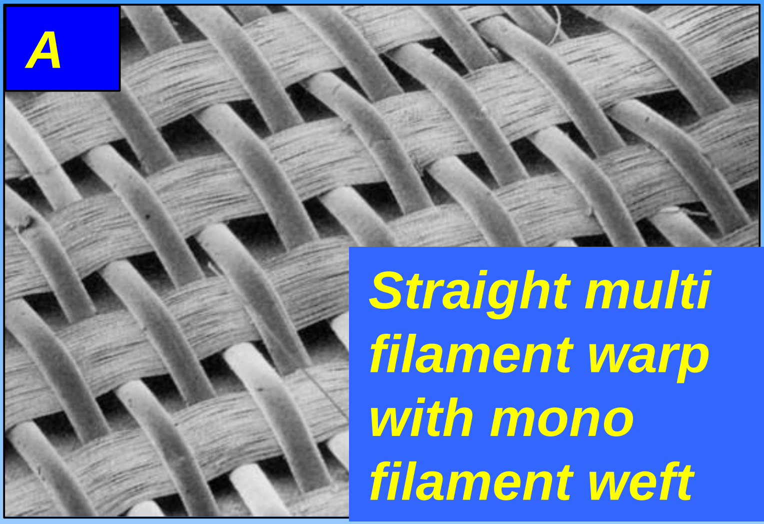
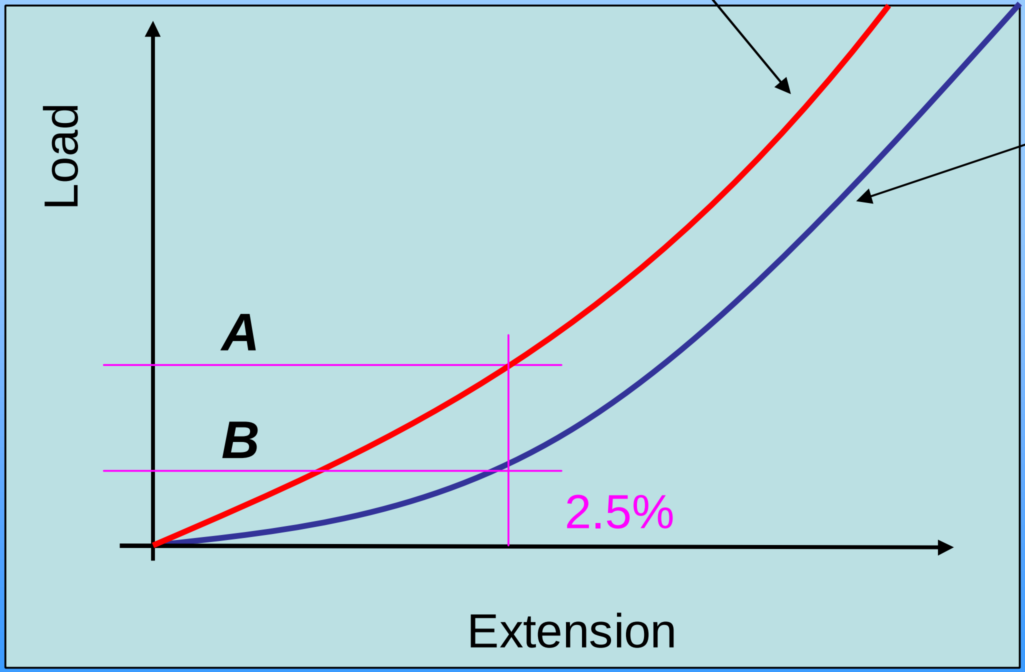
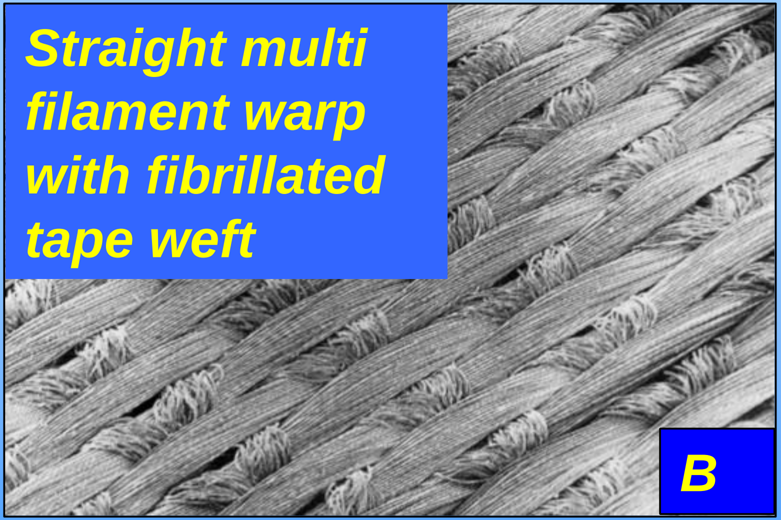


Straight multi filament warp with mono filament weft

Soil and particular compacted granular soil has its peak shear strength at between 3% and 5 % and it is important to call for the strength at 2.5% particularly for high strength geosynthetics as this can expose inadequate manufacturing expertise.



Straight multi filament warp with fibrillated tape weft



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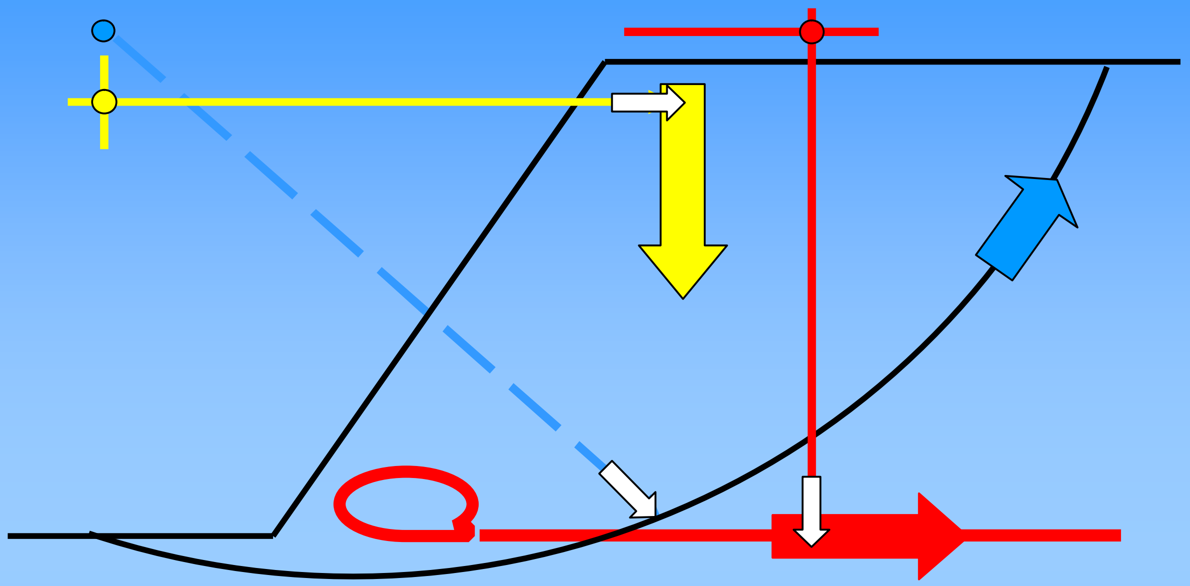
Reinforcing - Limit State

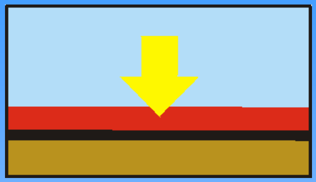


In almost all reinforcing geosynthetic applications the reinforcement works in conjunction with the soil.

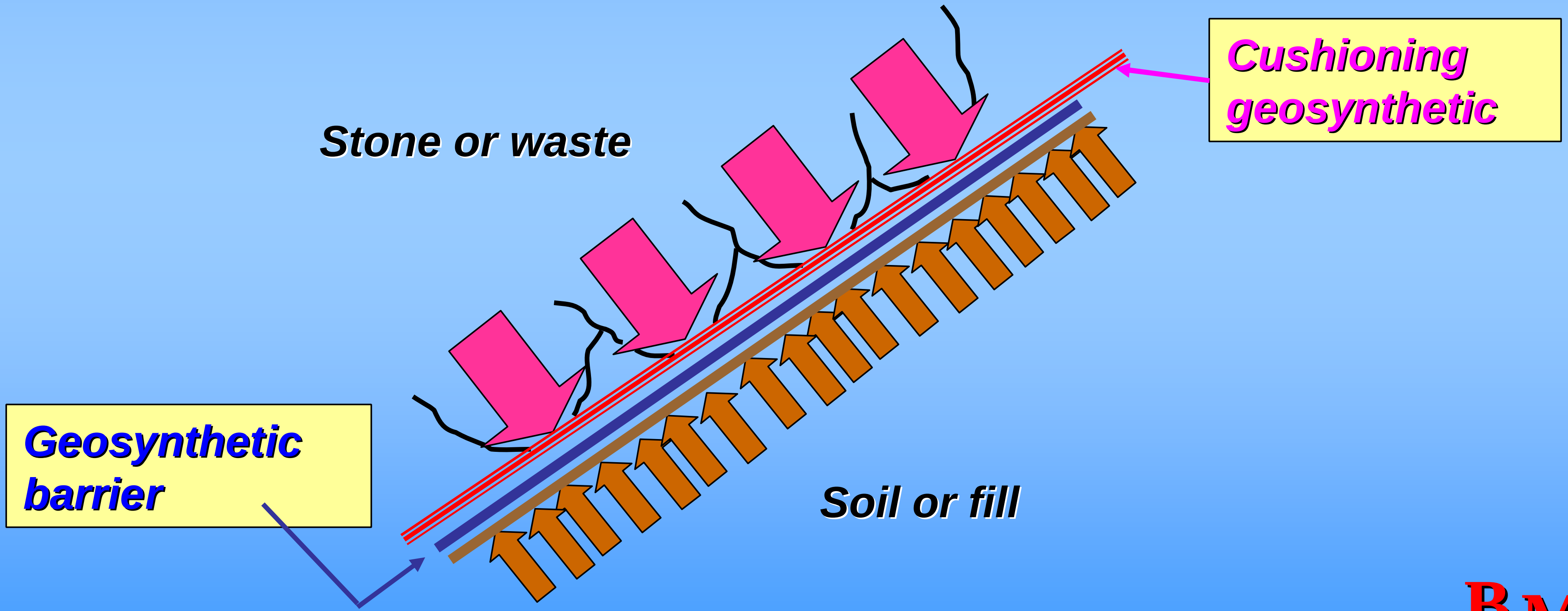
The strength at 6% deformation is a realistic limit state strength for a reinforcing geosynthetic as the soil shear resistance is reducing rapidly beyond the peak shear strength deformation.

If the ultimate strength of the geotextile is to be utilized in the analysis then the residual shear strength of the soil should be used and defined at the geosynthetics ultimate strength deformation.

Cushioning



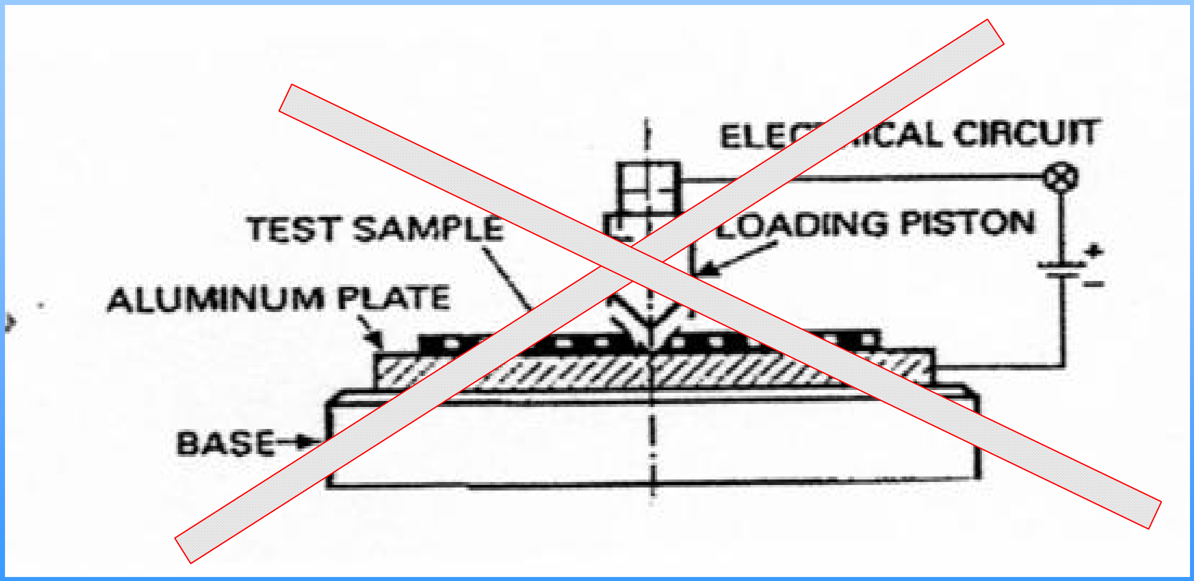
The use of a cushion layer to protect a geosynthetic barrier is common in landfill and other barrier applications.



Cushioning

Specifications based on weight per unit area should be rejected.
The physical properties are well covered by CBR and Drop Cone
The use of directional test such as Grab Tensile or slow tear prorogation test such Trapezoidal Tear are poor indicators of performance and should be deprecated and never used.

In isolation pin and pyramid puncture test (EN 14574) do not mirror the reality of protection efficiency and so inadequate cushion geosynthetic can exhibit excellent test values with these tests.



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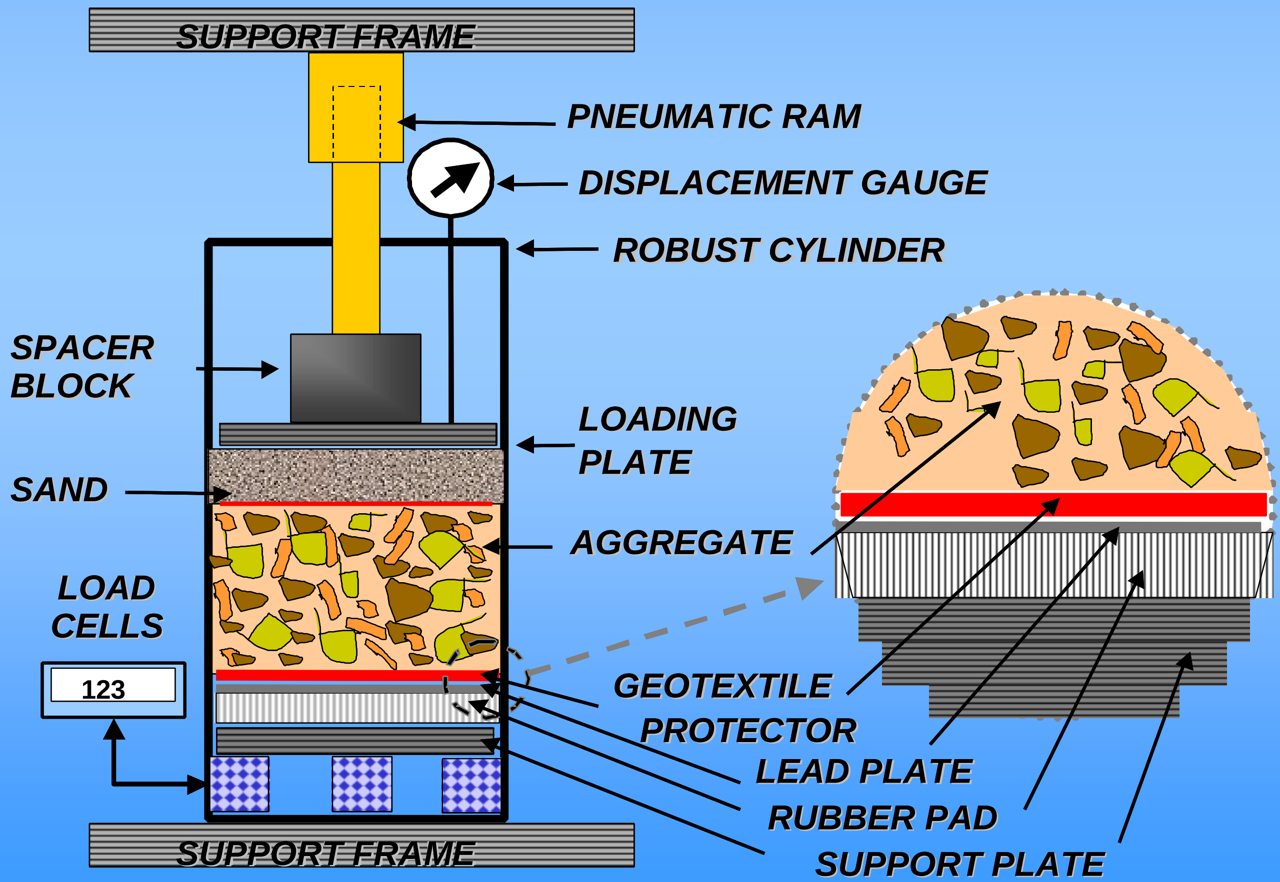
Cushioning

The cushioning geosynthetic specification should require the EN 13719 - Determination of long-term protection efficiency. This test allows the interaction of the geosynthetic barrier, the geosynthetic cushion and the cover aggregate.



The advantage with this test is that realistic loads and fill can be applied over time and that the deformations can be captured.

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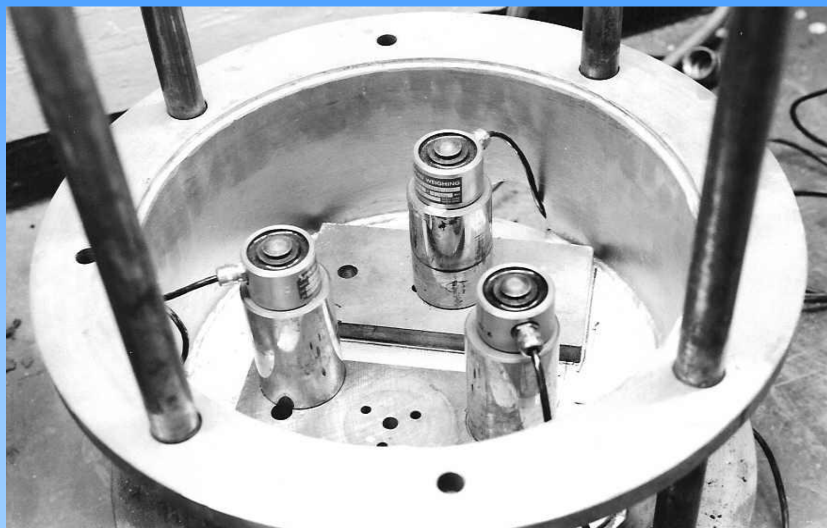
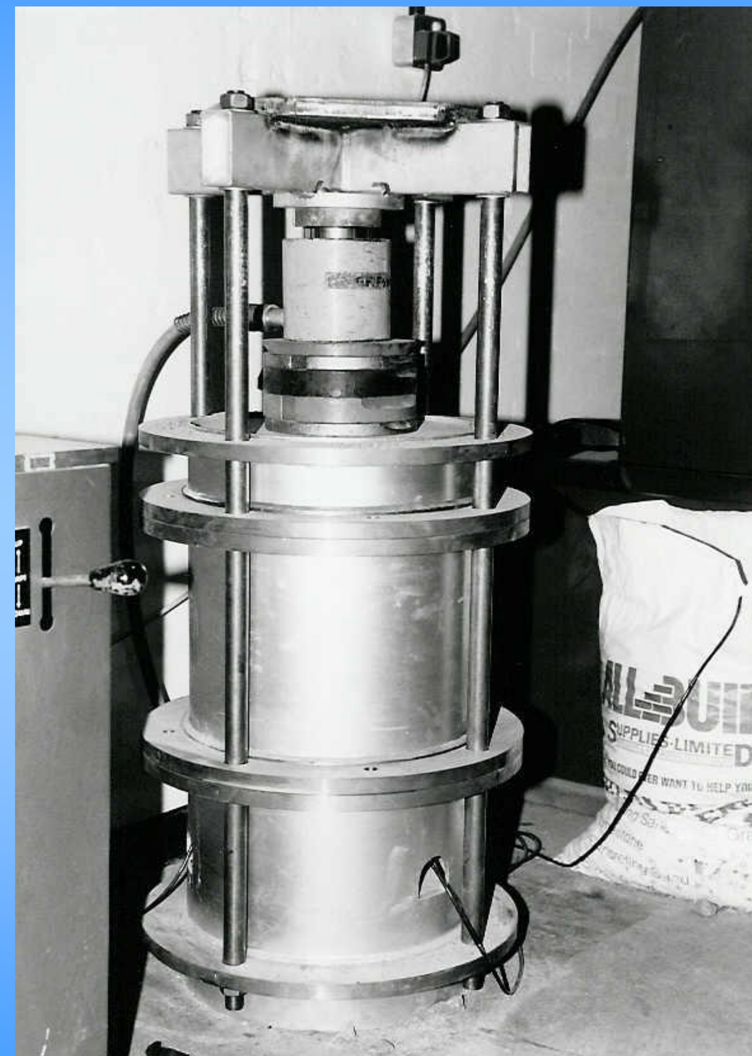
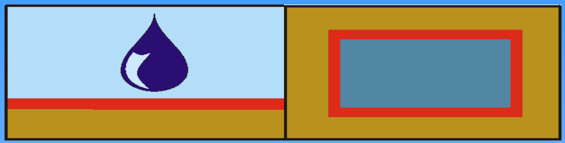
Cushioning





EN 13719 The % strain across the thee worst indentations

Barriers

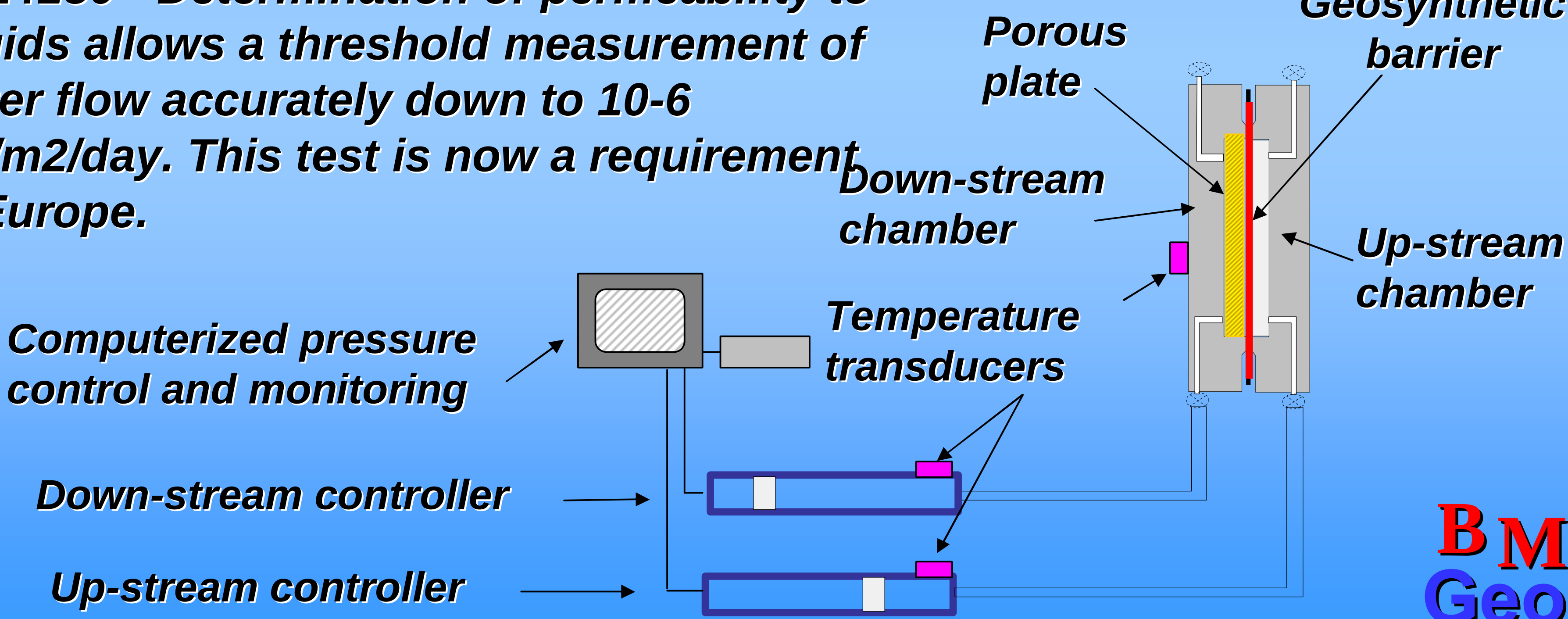


Polymeric barriers

Geosynthetic barriers are often specified by polymer rather than properties.

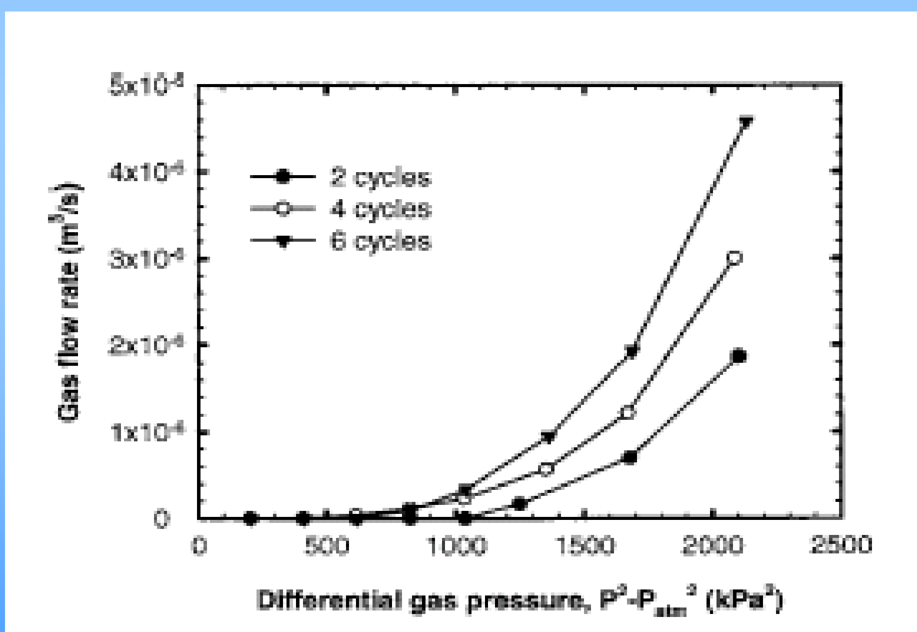
The prime property of any barrier is its resistance to liquid and gas; surprisingly these two characteristics are rarely specified.

EN14150 - Determination of permeability to liquids allows a threshold measurement of water flow accurately down to 10-6 m3/m2/day. This test is now a requirement in Europe.



Gas permeability of polymers

The ASTM D 1434 is widely used as the test procedure for the gas permeability of geosynthetics, however the ASTM F1769 - Measurement of Diffusivity, Solubility and Permeability of Organic Vapour Barriers using Flame Ionization Detector is a more meaningful test and it is hoped that ASTM F1769 will be the required test for gas transmission in both the USA and Europe the near future.



Effect of wetting and drying on the gas permeability of a GCL

Gas permeability of GCLs

The gas permeability of geosynthetic clay liners-barriers (GCL) is a critical issue. The European Geosynthetics Committee CEN TC189 has developed a test procedure which is provisionally in use and is in the process of being voted into a mandatory requirement in Europe.

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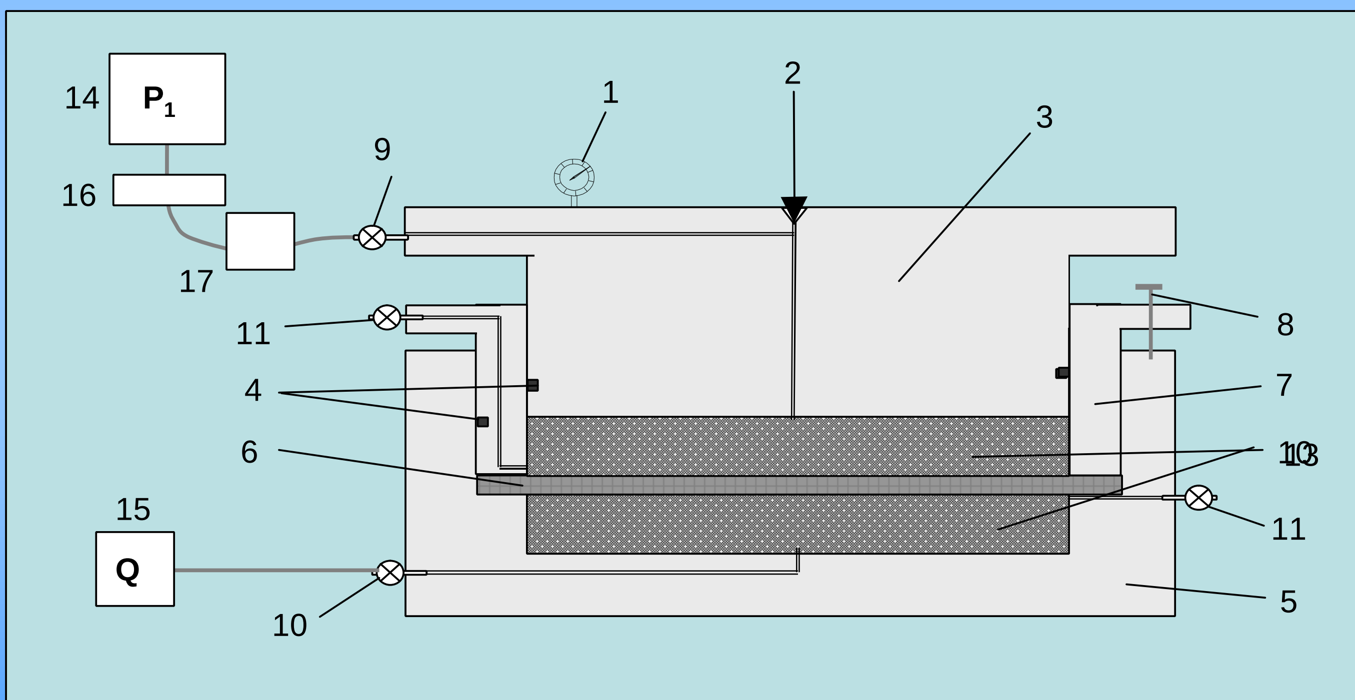
Gas permeability of GCLs

The gas permeability of geosynthetic clay liners (barriers) is a critical issue. The European Geosynthetics Committee CEN TC189 has developed a test procedure which is provisionally in use and is in the process of being voted into a mandatory requirement in Europe.



1. Normal stress
2. Piston
3. O-ring
4. Base
5. Valve for inlet gas
6. specimen
7. Cylinder for specimen edge containment
8. Screws to fixed cylinder to base
9. Valve for inlet gas
10. Valve for purge
11. Valve for outlet gas
12. Support material
13. Containment material
14. Gas tank
15. Gas flow meter Q
16. Inlet pressure regulator P1
17. Displacement gauge
18. Inlet pressure gauge P1

CEN TC189 - Work Item 97 - Geosynthetic clay barriers – Determination of the permeability to gases

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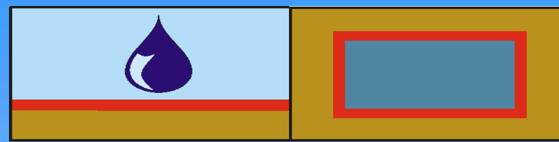
Test Method	Comment	Test method
Thickness	Too much emphasis is placed on this property; it is an identifier not a hydraulic property	EN 964-1 (GCL) EN 1849-2 (POLYMER)) EN 1849-1(BITUMIMOUS))
Density	This is an identifier, in the extreme it will indicate physical characteristics but has little to do with hydraulic properties	ASTM D1505 ASTM D792
Tensile Properties • yield strength • yield elongation (both directions)	Required properties	ISO527 ASTM D6693
Water permeability	Essential requirement	EN 14150 ASTM D5887 Index flux
Gas permeability	Essential requirement	ASTM F1769 CEN TC189 WI 97 ASTM D1434
Tear Resistance	Done more out of tradition than meaning, does not replicate site damage	ISO 34 (POLYMER) ASTM D1004 (POLYMER) EN 12310-1 (BITUMINOUS)
Puncture Resistance	This could be a meaningful test if modified but in its present slow strain mode it is worthless	ASTM D 4833 EN ISO 12236
Protection efficiency	Important test done in conjunction with cushion geosynthetic	EN 13719
Stress Crack Resistance	This is necessary but only has importance for HDPE	EN 14576 ASTM D5397
Carbon Black Content	A money maker for laboratories	ASTM D1603
Carbon Black Dispersion	An even bigger money maker for laboratories	ASTM D5596
Oven Aging	Good simple test	EN 14575 (POLYMER) EN ISO 13438 (GCL) Bituminous mod EN 14575
UV Resistance	A meaningful test if carried out correctly and will soon show if the carbon content or the UV stabilizer is deficient	EN 12224
Chemical degradation	Important test	EN 14414 (all)
Biological degradation	Often asked for, important for laboratory’s profitability, never known a geosynthetic to fail the test in 30 years of practice	EN 12225

Barriers Test methods

Barriers



When all these barrier properties are specified, tested and approved it is the seams that hold the key to the success of the functioning of the barrier. **SEAMS SEAMS SEAMS**

Seams are fabricated in the field, subject to poor support, hot and cold weather, rain and a large amount of human error.

Require that barrier is produced in the factory with ISO 9000 with CE approval and accreditation and demand to see factory control records (FPC) for the delivered product

The key to a successful geosynthetic barrier specification and installation is correct and diligent "Construction Quality Assurance" (CQA) on site

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Conclusions

A meaningful and precise geosynthetic specification will depend on the geosynthetic's function being well defined.

There are dozens of test procedures to describe all kinds of geosynthetic properties and characteristics, choose carefully and prioritise the key functional properties.

Do not ask for a property that has no standard means of definition, we would all like to know the resilient modulus at 1% elongation after 10E6 cyclical loadings but there is no standard test.

Use only control and testing laboratories that have full accreditation for all tests and that have an established ethical reputation.

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Conclusions – continued

Take advice from all quarters but remember sales people are there to sell, ask for advice but get the name of the technical manager, if they do not have one look elsewhere.

Specification are a developing, products change, new products arrive. Do not make the specification too ridged and be prepared to revise in the light of experience and knowledge, Establish and fixed specifications make the specifier and the supplier lazy and inattentive.

THANK YOU FOR LISTENING

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