Geosynthetics

David I. Cook

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1 Scope

Geosynthetics is now the generally accepted term for the whole range of ‘geo’ materials used in civil engineering. The main sub categories or families are geotextiles, geomembranes, geosynthetic clay liners (GCLs), geogrids and geocomposites.

The field of geosynthetics is a vast one. Many thousands of articles and dozens of books have been written on various aspects of these materials. It is not, therefore, possible, in this review, to provide a comprehensive coverage but rather a brief overview which should prove useful to newcomers to this subject. The constituent polymeric materials used to make these products are particularly highlighted.

The review will cover, in outline, the following aspects of geosynthetics:

- What they are made of, i.e., their constituent polymers
- How they are made
- What they are used for
- How they are tested

The author’s background is testing and characterisation of geosynthetics and so this topic is given special attention.

2 Introduction to Geosynthetics

2.1 General Description

Geosynthetics are sheet materials made, for the most part, from synthetic polymers. They have been used since the early 1970s by civil engineers to perform several major functions in geotechnical (soil) structures:

- Separation
- Reinforcement
- Drainage
- Filtration
- Protection
- Barrier to fluids (water, gases)

These functions will be discussed later under the individual geosynthetic family headings.

2.2 History

The reader is referred to an excellent series of articles in the magazine Geotechnical Fabrics Report which describe and reflect on the growth of the geosynthetics industry over the past 20 years (a.1-a.4). There are four papers, each covering a four year period. The first paper by Giroud (a.1) covers the early years 1983-1987 and highlights, amongst other things, the rise, during this period, in the use of geosynthetics for environmental applications, such as landfills, and the development of soil reinforcement.

A later article by Koerner (a.4) discusses the organisational, technical, design and testing changes which have taken place over the period 1998 to 2002.

2.3 Publications

There are several magazines published which specialise in the geosynthetics industry and its products:

- Geotechnical Fabrics Report (GFR) is published, nine times a year, by Industrial Fabrics Association International (IFAI), GFR is an official publication of the Geosynthetic Materials Association. This magazine contains articles of general interest and case studies written, generally, in a non-technical style. GFR issue yearly an excellent ‘Specifier’s Guide’ (a.5). This guide is a directory of geosynthetic products, applications and services such as testing, consultation and inspection.

- Geotextiles and Geomembranes is the official journal of the International Geosynthetics Society (IGS), and describes its function as ‘providing a forum for the dissemination of information amongst research workers, designers, users and manufacturers’. The articles tend to be detailed, researched based and very technical.

- Geosynthetics International published by IFAI is another official journal of IGS of interest to people involved in research, design, testing and specification of geosynthetics. Each bimonthly issue covers all aspects of materials, research and application technology relating to geosynthetics.
3 Geotextiles

3.1 Description and Manufacturing

According to the US standard ASTM D4439, a geotextile is defined as follows (a.6):

A permeable geosynthetic comprised solely of textiles. Geotextiles are used with foundation, soil, rock, earth or any other geotechnical engineering related material as an integral part of a human made project, structure or system.

Geotextiles were the first geosynthetics to be used in civil engineering. They are manufactured by conventional textile processes, namely, weaving, knitting and non-woven technology.

Woven and non-woven geotextiles are by far the most common.

The market for geotextiles, and other geosynthetics, changes from year to year. Various authors have conducted surveys, or at least commented on the use and consumption of geotextiles. Ghosh and Horrocks stated (112) that the annual market for geotextiles in 1995 was nearly 1,000 million m² or about 250,000 tonnes of raw materials, of which over 70% comprises polypropylene. More up to date information gives a world consumption of geotextiles of about 1,400 million m² (a.7) of which over half is used for separation and stabilisation.

Figure 1 shows the rise in world consumption of geotextiles from 1970 to 2000.

Bradley remarked (224) that in the UK the market was split roughly 65:35 between woven and non-woven products with between 60 and 70 different types of geotextile in 5 to 10 broad categories.

Full market surveys have been carried out by Frost and Sullivan for North America and Western Europe (296), and, earlier, for the USA only (333). Kulke and Associates carried out a survey of the world polyolefin market, which included geosynthetics (208).

As for the future, a market report by the Freedonia Group (a.8) estimates growth in the USA, for all geosynthetics, to be 4% per year up to 2006 with geotextiles accounting for the largest share of the geosynthetics demand (75%).

Finally, on the subject of market growth and share, Koerner (a.9) has provided an interesting comparison of the sales and value of geotextiles compared with the other geosynthetic categories mentioned in this review (Table 1).

![Figure 1](image_url)

**Figure 1**
Growth in world use of geotextiles, 1970-2000
### 3.1.1 Woven Geotextiles

Woven geotextiles are manufactured on a loom from various types of yarn.

The main warp (threads running along the length of the loom) and weft yarns (threads crossing at right angles to the warp), utilised in the construction of woven geotextiles, are:

- **Monofilament**: a yarn of one filament
- **Multifil**: a yarn comprising many fine continuous filaments twisted or intermingled together
- **Staple**: short lengths of fibre twisted together to form a yarn
- **Slit film**: tape like strands formed by splitting a continuous polymer sheet
- **Slit film yarn**: combination of slit films twisted to make a yarn

Plain weave, where the warp and weft threads are alternated through the fabric, is usually employed for geotextile and other industrial textiles. Occasionally other weave structures such as twill or basket patterns may be encountered (a.10).

Woven geotextiles, depending on the component yarns, can be much stronger than non-wovens. They are also, generally, much stiffer (higher modulus) and, therefore, do not stretch very much when load is applied. Wovens also tend to be less permeable to water than non-wovens.

Further information on weaving technology can be found in references a.9, a.10 and a.11.

### 3.1.2 Non-Woven Geotextiles

The two most important processes for manufacturing non-woven geotextiles are spun bonding and needling. In spun bonding, continuous filaments of a thermoplastic polymer are extruded onto a moving conveyor belt to form a web. The web, or mat of filaments, is then bonded, usually by a thermal treatment, before being wound up into a roll. In heat bonding, the filaments are melted together at their cross over points. One prominent geotextile manufacturer uses the heterofil principle to adhere the filaments, in which the filament sheath consists of a polymer with a lower softening point temperature than that of the core.

In the needle punching process, the fibres or filaments are consolidated by repeatedly pushing barbed needles through the fibrous web. The needles orientate many of the fibres vertically and thus achieve a high degree of mechanical bonding. Needle punched fabrics tend to be thicker and less stiff than spun bonded materials. An article in GFR (a.12) gives a good description of needle punching. It covers the basic manufacturing process, products and markets (including geotextiles) and recent advances in this technique.

The geotechnical applications of non-woven fabrics have been reviewed (206). The author deals with filtration, subsurface drainage, fin drains and erosion control and several other outlets.

### 3.1.3 Knitted Geotextiles

Knitted geotextiles are much less common than woven and non-woven. Warp, rather than weft knitting (a.10), is the preferred manufacturing technique, often with
Geosynthetics

weft insertion. Such fabrics, usually made from polyester for strength and stiffness, are used mainly for reinforcement.

3.2 Polymers

The most common polymers used in the manufacture of geotextiles are polypropylene and polyester.

Polyamide (nylon) and polyethylene feature to a much smaller extent. Certain applications, where heat resistance is required, employ glass fibres and yarns. Natural materials with low biological resistance such as jute and sisal are utilised for erosion control.

The choice of the polymer is governed by two factors: economics and properties. The availability and cost of the polymer obviously influence the decision. The characteristics of the geotextile, are determined to some extent by the polymer. This applies particularly to durability, i.e., the ability of the polymer to withstand environmental agencies such as heat, light and chemicals.

3.2.1 Polyester

The general repeat unit of polyester polymer is:

\[ -O-R-CO-R'-CO- \]

Nearly all the polyester used for textiles, including geotextiles, is polyethylene terephthalate (PET) made by polymerising terephthalic acid and ethylene glycol. Unless otherwise specified, polyester refers to PET in this review.

A large amount of clothing, and other domestic textiles, has been made from PET polyester for over forty years. Its cost, strength, durability and easy care properties have proved invaluable for this purpose. It was natural, therefore, that PET and other polyesters should be considered for industrial and engineering materials such as geotextiles.

Polyester is a thermoplastic polymer made by melt spinning continuous filaments. These filaments can be made into a tow and cut into short lengths, to make staple, or stretched (drawn) after spinning to produce a multifil yarn. The properties of this yarn, especially tenacity (strength per unit weight), can be varied over a wide range by adjustment of:

- Resin properties; molecular weight, intrinsic viscosity, etc.
- Spinning conditions; quench, wind up speed, etc.
- Drawing conditions; temperature, draw ratio, etc.

For example a high draw ratio (extent of stretching) orients the molecules to such a degree that strong, high tenacity filaments are produced. Variation in yarn decitex (weight per unit length) and adjustment of weaving parameters, such as end (warp) and pick (weft) density, can be employed to produce geotextile fabrics with a wide range of strength (10 to 1000 kN/m) and stiffness (modulus) properties (a.5).

Geotextiles made from polyester have the following advantages over polypropylene of similar weight and construction:

- Stronger
- Greater elastic modulus
- Less prone to creep, i.e., extension under constant load with time
- Higher resistance to UV light and oxidation, less need for anti-oxidant and light resistance additives.

Polypropylene scores over polyester under the following criteria:

- Lighter
- Better chemical resistance, especially to alkaline (high pH) environments and other aqueous media
- Lower cost.

3.2.2 Polypropylene

The chemical formula of polypropylene is:

\[ -\bigg(\begin{array}{c} \text{H} \\ \text{C} \\ \text{H} \\ \text{CH}_3 \end{array}\bigg)_n \]

The hydrocarbon backbone and nonpolar nature of the side groups in polypropylene, confer good resistance
to aqueous solutions, e.g., acids and alkalis, but less good resistance to hydrocarbons such as petroleum and diesel fuel. As indicated in Section 3.2.1, polypropylene’s lower resistance to gradual extension under constant load (creep) makes the polymer less useful than polyester for reinforcement end uses, where significant creep would result in unacceptable deformation of the geotechnical structure.

3.2.3 Polyamide (Nylon)

Various nylon s can be made by using monomers containing different numbers of carbon atoms. Nylon 66, so called because each monomer contains six carbon atoms, is produced by heating adipic acid with hexamethylene diamine.

\[
\text{HOOC(CH}_2\text{)}_{4}\text{COOH + NH}_2\text{(CH}_2\text{)}_{6}\text{NH}_2 \rightarrow \text{CO(CH}_2\text{)}_{4}\text{CO NH(CH}_2\text{)}_{6}\text{NH}
\]

Geotextiles made from nylon are relatively rare these days. Polyamides do not have the strength, elastic modulus and low creep of polyester. Polyamides are also more susceptible to acid hydrolysis than polyesters although resistance to acids is better.

3.2.4 Polyethylene

Polyethylene (polythene) is made by polymerising ethylene and has the following repeat unit:

\[
\overset{\text{CH}_2}{\text{CH}_2}\text{ }\overset{\text{CH}_2}{\text{CH}_2}
\]

There are many forms of polyethylene, all with different properties. The various types of polyethylene will be discussed in more detail in Section 4 on geomembranes.

Geotextiles made wholly from polyethylene are rare. The commonest usage of polyethylene in geotextiles is as a low softening point sheath surrounding a higher softening point polypropylene core in spun bonded, non-woven fabrics.

3.2.5 Natural Fibres

Natural, as distinct from man made, fibres like jute, coir, coconut, sisal, ramie, etc., have been utilised in applications where durability is not an issue. Products designed to reduce soil erosion are the commonest end use for such materials (about 13% by area of all geotextiles in 2000), where gradual degradation over a period of a year or two is an advantage over the more durable synthetic products.

Smith has conducted an in depth study of the potential market for some natural fibres (sisal and henequen) as constituents of geotextiles (a.7).

A geotextile made from synthetic (PP) and natural fibres (ramie) has been reported in Textile Horizons (359).

3.2.6 Comparative Properties

The comparative properties of all four geotextile synthetic polymers are shown subjectively in Table 2.

3.3 End Uses

It is important to distinguish between the end uses and functions of geotextiles. End uses or applications refer to the geotechnical structures in which the geotextiles are incorporated. Function is a description of the role the material is performing in the structure.

There are a number of papers which discuss the uses of geotextiles (17, 304). A review is given of the applications of non-woven geotextiles in High Performance Textiles (206).

The principal functions of geotextiles are:

- Separation – A geotextile is used to permanently separate two distinct layers of soil in, say, a roadway to be constructed across a poorly drained, fine grained soil. The geotextile, which is laid down prior to laying the gravel, keeps the soft, underlying soil from working its way up into the gravel. It also prevents the gravel from punching down into the soft soil.

- Reinforcement – Geotextiles, which are good in tension and poor in compression, can be used to strengthen or reinforce soil which, in contrast, is good in compression but poor in tension. Geotextiles for example, can reinforce a soft foundation soil which would normally be too weak to support an overlying structure like a road.
• Drainage and filtration – The geotextile acts as a filter allowing water to pass while at the same time stopping fine grained soil from entering and contaminating adjacent coarse grained layers.

• Protection – The geotextile covers and prevents damage by an external agency or overlaying layer, e.g., protection of geomembranes from drainage gravel in a landfill.

There are many applications and end uses for geotextiles in which the material performs one or more of the above functions (a.9). The importance of the function depends on the application. For example, filtration and drainage are the primary functions for the construction of drains whereas reinforcement is the key function for steep side embankments and earth walls. Table 3 lists some of the more common geotextile applications and functions.

### 3.4 Testing and Properties of Geotextiles

The properties of the geotextile depend on the nature and manufacturing conditions of the fabric and constituent polymer which are varied and adjusted to produce the required values.

The main committees responsible for developing test methods for geotextiles, and other geosynthetics, are:

• In Europe: CEN 189 committee

• Internationally: ISO TC38/SC21 committee

• In UK: British Standards (BS) committee B553

• In America: ASTM D35 committee

There are also standards organisations in many other countries, Canada, Australia, South Africa and most European countries. However, for geotextiles, and most other materials, European countries no longer produce standards. The national committees, like B553 in the UK, feed their views and proposals to the controlling European and international committees.

The standard methods are known as either ‘index’ or ‘performance’ tests. Index tests tend to be simple, quick and relatively cheap and do not attempt to simulate site conditions. They are used for conformance purposes, i.e., to confirm, say, that delivered material has the same properties as the original sample or as those claimed in the manufacturers’ literature. Performance tests, on the other hand, attempt to

---

| Table 2 Comparative properties of geotextile polymers (a.13) |
|---------------------------------|----------------|----------------|----------------|----------------|
| Property                        | Polyester  | Polyamide  | Polypropylene | Polyethylene  |
| Cost                            | H          | M          | L             | L             |
| Weight                          | H          | M          | L             | L             |
| Strength                        | H          | M          | L             | L             |
| Modulus                         | H          | M          | L             | L             |
| Extension at break              | M          | M          | H             | H             |
| Creep                           | L          | M          | H             | H             |

**Resistance to:**

<table>
<thead>
<tr>
<th>Property</th>
<th>Polyester</th>
<th>Polyamide</th>
<th>Polypropylene</th>
<th>Polyethylene</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV light</td>
<td>H</td>
<td>M</td>
<td>H (stabilised)</td>
<td>H (stabilised)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>M (unstabilised)</td>
<td>L (unstabilised)</td>
</tr>
<tr>
<td>Alkaline hydrolysis</td>
<td>L</td>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>Acid hydrolysis</td>
<td>H</td>
<td>L</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>Microorganisms</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>Hydrocarbons (fuel)</td>
<td>M</td>
<td>M</td>
<td>L</td>
<td>L</td>
</tr>
</tbody>
</table>

_H: High, M: Medium, L: Low_
reproduce at least some of the site conditions in the laboratory. Performance tests, therefore, tend to be more expensive and take longer to perform.

The tests are generally subdivided into the following major categories:

- Characterisation
- Mechanical
- Hydraulic
- Durability

There are too many tests to describe the background, rationale and procedure for each one, or even each category. Instead some key information on the most important tests is shown in Table 4 viz. category, property, standard number, comments on use, principle and procedure and some literature references.

Selected geotextile test methods will now be discussed in more detail, especially, where not already mentioned, those properties where the nature of the polymer can have a significant influence.

3.4.1 Tensile and Other Mechanical Properties

Tensile strength is probably the most important property of geotextiles, along with other tensile characteristics, derived from the stress-strain curve, such as stiffness, toughness and elongation.

The importance of tensile properties is clearly paramount where the function of the geotextile is to reinforce a soil structure. In the current European and

---

Table 3 Geotextile end uses and functions (examples)

<table>
<thead>
<tr>
<th>End use/application</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roads (paved and unpaved)</td>
<td>Separation of subgrade and stone base</td>
</tr>
<tr>
<td></td>
<td>Reinforcement: over soft soils</td>
</tr>
<tr>
<td>Airfields</td>
<td>Separation of subgrade and stone base</td>
</tr>
<tr>
<td></td>
<td>Reinforcement: over soft soils and lateral containment</td>
</tr>
<tr>
<td>Railways</td>
<td>Separation of subgrade and ballast</td>
</tr>
<tr>
<td></td>
<td>Reinforcement: over soft soils</td>
</tr>
<tr>
<td></td>
<td>Drainage beneath ballast</td>
</tr>
<tr>
<td>Embankments/steep slopes</td>
<td>Reinforcement and stabilisation of embankment soil</td>
</tr>
<tr>
<td></td>
<td>Separation of embankment and foundation soil</td>
</tr>
<tr>
<td>Retaining walls</td>
<td>Drainage behind walls</td>
</tr>
<tr>
<td></td>
<td>Reinforcement of constructed walls (119)</td>
</tr>
<tr>
<td>Sports fields</td>
<td>Separation of dissimilar materials</td>
</tr>
<tr>
<td>Earth and rock dams</td>
<td>Separation of various zones</td>
</tr>
<tr>
<td></td>
<td>Reinforcement of the dam components</td>
</tr>
<tr>
<td></td>
<td>Chimney drain or drainage gallery</td>
</tr>
<tr>
<td>Erosion control</td>
<td>Stabilisation of slopes by encouraging growth of vegetation and reducing water run off speed</td>
</tr>
<tr>
<td>River banks</td>
<td>Protection and stabilisation</td>
</tr>
<tr>
<td>Landfills</td>
<td>Separation of geomembrane and sand drainage layer</td>
</tr>
<tr>
<td></td>
<td>Protection of geomembrane from subsoil, drainage or base layer</td>
</tr>
<tr>
<td></td>
<td>Filtration of leachate</td>
</tr>
<tr>
<td></td>
<td>Drainage beneath geomembranes</td>
</tr>
<tr>
<td>Agriculture, nursery and landscape</td>
<td>Weed growth barriers, tree containers, shade and protection covers (187)</td>
</tr>
<tr>
<td></td>
<td>Crop enhancement by providing beneficial microclimate (a.7)</td>
</tr>
<tr>
<td>Category</td>
<td>Property</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Characterisation</td>
<td>Sampling</td>
</tr>
<tr>
<td></td>
<td>Sampling</td>
</tr>
<tr>
<td></td>
<td>Thickness (single layers)</td>
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<tr>
<td></td>
<td>Thickness</td>
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<tr>
<td></td>
<td>Thickness (multi-layers)</td>
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<tr>
<td></td>
<td>Thickness</td>
</tr>
<tr>
<td></td>
<td>Mass per unit area</td>
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<tr>
<td></td>
<td>Mass per unit area</td>
</tr>
<tr>
<td>Mechanical</td>
<td>Tensile properties</td>
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<td>Tensile properties</td>
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<td>Tensile properties</td>
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<td>Tensile properties</td>
</tr>
<tr>
<td></td>
<td>Tensile test for joints and seams</td>
</tr>
<tr>
<td></td>
<td>Puncture (California bearing ratio (CBR))</td>
</tr>
<tr>
<td></td>
<td>Puncture (pin)</td>
</tr>
<tr>
<td></td>
<td>Dynamic perforation (Cone drop)</td>
</tr>
<tr>
<td></td>
<td>Tear strength</td>
</tr>
<tr>
<td></td>
<td>Friction (direct shear)</td>
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<tr>
<td></td>
<td>Friction (inclined plane)</td>
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<tr>
<td></td>
<td>Pull out test</td>
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<tr>
<td></td>
<td>Burst strength</td>
</tr>
<tr>
<td></td>
<td>Installation damage</td>
</tr>
<tr>
<td></td>
<td>Installation damage</td>
</tr>
<tr>
<td>Category</td>
<td>Property</td>
</tr>
<tr>
<td>--------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>Hydraulic</td>
<td>Pore size (dry sieving)</td>
</tr>
<tr>
<td></td>
<td>Pore size (dry sieving)</td>
</tr>
<tr>
<td></td>
<td>Pore size (wet sieving)</td>
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<tr>
<td></td>
<td>Water flow (normal)</td>
</tr>
<tr>
<td></td>
<td>Water flow (in plane)</td>
</tr>
<tr>
<td></td>
<td>Water flow (in plane)</td>
</tr>
<tr>
<td></td>
<td>Break through head</td>
</tr>
<tr>
<td>Durability</td>
<td>Durability criteria test</td>
</tr>
<tr>
<td></td>
<td>Creep/creep rupture (tensile)</td>
</tr>
<tr>
<td></td>
<td>Abrasion (sliding block)</td>
</tr>
<tr>
<td></td>
<td>Protection efficiency</td>
</tr>
<tr>
<td></td>
<td>Protection efficiency</td>
</tr>
<tr>
<td></td>
<td>Protection efficiency</td>
</tr>
<tr>
<td></td>
<td>UV light (weathering)</td>
</tr>
<tr>
<td></td>
<td>Oxidation</td>
</tr>
<tr>
<td></td>
<td>Liquids</td>
</tr>
<tr>
<td></td>
<td>Hydrolysis</td>
</tr>
<tr>
<td></td>
<td>Microorganisms</td>
</tr>
</tbody>
</table>
international methods, a 20 cm wide specimen is stretched uniaxially, at constant strain rate, until failure results. The specimens are wider than conventional textile test strips (5 cm) to reduce, to some extent, the effect of material ‘necking’ or ‘waisting’ during extension. This necking occurs in the ‘in isolation’ laboratory test but not in an actual geotechnical structure where the soil covering confines the material and allows deformation in one plane only to take place; an effect known as plane strain. Confined tensile strength, where the specimen is prevented from necking, has been measured by McGown and others (a.14). The test is complex and time consuming but the results of this performance test give a better reproduction of site conditions than the ‘in isolation’ uniaxial test.

Section 3.2 explains, to some degree, how the nature of the polymer and fabric can determine the strength and stiffness of the geotextile.

Figure 2 illustrates, schematically, the very different stress-strain curves of three common geotextiles. The woven is strong, stiff and has a low extension at break. The non-wovens are weaker and have much higher breaking extensions.

3.4.2 Hydraulic Properties

One of the major functions that geotextiles perform is that of filtration. Geotextiles are, thus, designed to be permeable and allow water to pass across their plane and retain the larger soil particles. Cross plane (normal) water flow is affected by the properties of the fabric, e.g., the size and distribution of the holes in the material.

The pores are determined by the structure of the weave in woven fabrics or the orientation and density of the individual filaments in the case of non-wovens. The constituent polymer, therefore, plays very little part in affecting the porosity and hydraulic properties of geotextiles. Bhatia and Smith confirmed, in a major study (152) that geotextile structure, rather than polymer properties, determined the pore size distribution of geotextiles.

3.4.3 Durability

The polymer, rather than the fabric structure, has a much larger influence over durability characteristics than mechanical and hydraulic properties. Durability refers to those environmental agencies, such as weathering, light, heat, chemicals and microorganisms, which could affect the life of a geotextile. Reference is made at this point to a very useful book by Brown and Greenwood entitled ‘Practical Guide to the Assessment of the Useful Life of Plastics’ (10). This book contains much useful information on durability tests and life prediction of geosynthetic and other polymers. Other good general reviews are by D’Souza and Horrocks (360) and Wrigley (363).
A conference on ‘Durability and Ageing of Geosynthetics’ was held at the Geosynthetic Research Institute in 1988. Sessions covered all geosynthetic categories with special emphasis on long-term performance of these materials in waste containment applications (312).

### 3.4.3.1 Microorganisms

As shown in Table 2, all the common geotextile polymers are unaffected by microorganisms, bacteria and fungi. Good confirmation of this resistance has been shown by Ionescu and co-workers (a.15) who exposed polypropylene and polyester fabrics for 5 to 17 months to a range of media, including three strains of bacteria. No significant effect on permeability, strength or chemical change to the polymer was detected.

Although bacteria do not feed on, or otherwise damage, geotextile polymers, they can still, by growing on the surface of fabric, block the pores and thus destroy its function as a filter. There is a long-term flow test to determine the potential for complete fabric clogging, over a period of time, by either ordinary soil particles or bacterial growth. This is the Gradient Ratio test (a.7, a.16) in which a sample of site soil or bacteria is placed in a cylinder. Instead of measuring flow rates, the hydraulic head, at various locations in the soil column, is measured. Head differences are converted to hydraulic gradients and a gradient ratio is calculated. This ratio will rise with time if the fabric is gradually becoming clogged for some reason, e.g., bacterial growth.

### 3.4.3.2 Weathering and UV Light

Sunlight is an important cause of degradation for all organic materials, including synthetic polymers.

The energy from the sun which causes polymer degradation is in the ultraviolet (UV) region. UVA (400 to 315 nm) causes some degradation, UVB (315 to 280 nm) can cause severe polymer damage. The actual degradation is caused by photons of light breaking the chemical bonds of the polymer. For each type of bond there is a threshold wavelength for bond scission above which bonds will not break. There are changes in both intensity and spectrum of sunlight over the seasons, e.g., a reduction in the shorter wavelength UV radiation during the winter months. Location, temperature, cloud cover, wind and moisture are also factors which can affect the UV degradation of polymers. Laboratory simulations of all these conditions is very difficult. It is, therefore, not straightforward to use laboratory weathering results to predict fabric life in field and site conditions, although crude rules of thumb exist for different parts of the world. The standard European test (BS EN 12224) has a weathering test involving rain as well as a light component. This is achieved by spraying the sample with water for 1 hour after every 5 hours of UV light exposure.

Although geotextiles are, in most cases, eventually buried and thus protected from the weather, in some end uses they remain permanently uncovered (e.g., silt fences) and in all cases are exposed during installation or if stored outdoors. Geotextile polymers, if untreated, can be especially sensitive to UV light and oxidation. Carbon black and other materials are added to the polymers as UV absorbers.

Rauman (a.8) demonstrated the susceptibility of several commercial geotextiles to UV radiation. He showed, for example, that a certain polypropylene fabric could lose over 90% of its original strength after eight weeks of exposure to Florida sunlight.

### 3.4.3.3 Ageing

Polymer ageing generally refers to the degrading effect of temperature and time. The chemical breakdown is by a process of oxidation with a similar mechanism to that of radiation. The current, very simple, test (ENV ISO 13438) is to measure the fabric strength before and after oven exposure at an elevated temperature. However, a new, more realistic and predictive test, is under development which employs high pressure oxygen (47).

### 3.4.3.4 Chemical Resistance

Section 3.2.5 referred to the relative chemical resistance of the main geotextile polymers. Polyolefins, like polypropylene and polyethylene, have a better chemical resistance than polyester to the chemicals likely to be encountered in most applications. Within the polyethylene range, the higher the density or crystallinity the better the chemical resistance.

There is a test specifically for assessing the resistance of polyester to hydrolysis. The test conditions are 28 days in water at 95 °C (66, 68, 220).

Another test, for all geotextile polymers, determines the effect of acid (dilute sulphuric acid, pH 3) and alkali
(saturated calcium hydroxide solution, pH 12). These acid and alkaline conditions are regarded as the extremes likely to be met in a soil environment.

A third screening test, under development, again challenges the fabrics with acid and alkali but in addition offers a third method which simulates a typical landfill leachate. The synthetic leachate contains 14 chemicals, many of which are organic acids. As for other durability tests, tensile strength is measured before and after treatment.

Reference a.9 provides a useful Table (p.107) which shows the effect of pH on the degradation of various geotextiles (20 °C for 120 days). The work showed, for example, that a non woven geotextile made from polyester staple fibres, lost half of its strength after exposure to sodium hydroxide solution for 120 days at 20 °C.

### 3.5 Construction Products Directive: CE Marking

A European Directive, which is relevant to geotextiles and related products is the Construction Products Directive (CPD), 89/106/EEC. This directive requires that all construction products (including geotextiles), used in the civil engineering and building industries, shall be CE marked after satisfying the requirements of the appropriate application or ‘Required Characteristic Standard’. Compliance with the directive is compulsory in order to permit the placing on the market and the free movement of regulated goods within Europe, irrespective of their origin. The CE mark enables the inspection authorities to confirm that the products satisfy the regulations.

The harmonised requirement standards (number and end use) for geotextiles are given in Table 5.

<table>
<thead>
<tr>
<th>Standard</th>
<th>End-use</th>
<th>Year</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BS EN 13249</td>
<td>Roads</td>
<td>2001</td>
<td>Geotextiles and geotextile-related products. Characteristics required for use in the construction of roads and other trafficked areas (excluding railways and asphalt inclusion)</td>
</tr>
<tr>
<td>BS EN 13250</td>
<td>Railways</td>
<td>2001</td>
<td>Geotextiles and geotextile-related products. Characteristics required for use in the construction of railways</td>
</tr>
<tr>
<td>BS EN 13251</td>
<td>Earthworks</td>
<td>2001</td>
<td>Geotextiles and geotextile-related products. Characteristics required for use in earthworks, foundations and retaining structures</td>
</tr>
<tr>
<td>BS EN 13252</td>
<td>Drainage</td>
<td>2001</td>
<td>Geotextiles and geotextile-related products. Characteristics required for use in drainage systems</td>
</tr>
<tr>
<td>BS EN 13253</td>
<td>Erosion control</td>
<td>2001</td>
<td>Geotextiles and geotextile-related products. Characteristics required for use in erosion control works (coastal protection, bank revetments)</td>
</tr>
<tr>
<td>BS EN 13254</td>
<td>Reservoirs and dams</td>
<td>2001</td>
<td>Geotextiles and geotextile-related products. Characteristics required for use in the construction of reservoirs and dams</td>
</tr>
<tr>
<td>BS EN 13255</td>
<td>Canals</td>
<td>2001</td>
<td>Geotextiles and geotextile-related products. Characteristics required for use in the construction of canals</td>
</tr>
<tr>
<td>BS EN 13256</td>
<td>Tunnels</td>
<td>2001</td>
<td>Geotextiles and geotextile-related products. Characteristics required for use in the construction of tunnels and underground structures</td>
</tr>
<tr>
<td>BS EN 13257</td>
<td>Solid waste</td>
<td>2001</td>
<td>Geotextiles and geotextile-related products. Characteristics required for use in solid waste disposals</td>
</tr>
<tr>
<td>BS EN 13265</td>
<td>Liquid waste</td>
<td>2001</td>
<td>Geotextiles and geotextile-related products. Characteristics required for use in liquid waste containment projects</td>
</tr>
</tbody>
</table>
These EN requirement standards instruct manufacturers to declare the mean value and tolerance of certain product characteristics. The required characteristics depend on the end use and function (separation, filtration, etc.) of the fabric. These characteristics are determined by some of the test methods listed in Table 3. Some tests (referred to as H tests in the standards) are mandatory, i.e., required by Mandate M/107 issued by the European Community to the European standardisation committee for geotextiles, CEN 189. Some (referred to as A tests in the standards) are relevant to all conditions of use. The A tests are not legally required but are commercially important. A third test category (S) is relevant to specific conditions of use.

For more information and detail on the CPD and CE marking of geotextiles, the reader is recommended to consult a relevant and useful web site on quality and standardisation of geotextiles (www.vinci-quality.com).

It should be noted that ‘geotextile related products’ includes all other categories of geosynthetic except geomembranes and GCLs. The latter two groups are now known as ‘geosynthetic barriers’ and are in a separate CPD sector from geotextiles and related products.

The application standards for geosynthetic barriers are, at the time of writing, still at the provisional stage (prENs). There are five provisional geosynthetic barrier standards (www.vinci-quality.com):

- prEN 13361 reservoir and dam construction
- prEN 13362 canal construction
- prEN 13491 fluid barrier in tunnel and underground structures
- prEN 13492 liquid waste containment
- prEN 13493 solid and hazardous waste storage

4 Geomembranes

4.1 Description and Manufacturing

Geomembranes are thin, flexible sheets of material with very low permeability. They are manufactured from synthetic or bituminous products and may be strengthened with a fabric or film. Geomembranes are employed invariably as a barrier to prevent the passage of gases and fluids.

A commonly accepted definition of a geomembrane from the ASTM is:

A geomembrane is a continuous membrane liner or barrier having sufficiently low permeability to control migration of fluids in a constructed project, structure or dam.

The original geomembranes were made of butyl rubber. Nowadays, polyvinyl chloride (PVC) or some form of polyethylene account for a high proportion of the total geomembrane usage. The different types of geomembrane polymer will be discussed in more detail later (Section 4.2).

The manufacture of geomembranes commences with the production of the raw materials, i.e., the polymer resin and a wide range of additives such as stabilisers, plasticisers, softeners, fillers, processing aids etc.

The raw materials can then be processed in three ways:

The first method produces the simplest type of geomembrane; single ply and non-reinforced. In this method the raw materials are blended and compounded before being extruded as sheets or cylinders. The extruder produces sheet material 0.1 to 5 mm thick and 1 to 5 m wide. Calendering, or pressing the sheets between counter rotating rollers, works them into uniform thickness and improves the mechanical properties. Full thickness sheets can also be blown into a large long bubble which is cut and opened into the final sheet form.

In the second method, multi-ply geomembranes are made by laminating several layers together. Laminated geomembranes can be non-reinforced or reinforced by inclusion of a fabric scrim between the layers. The scrim improves the mechanical properties (e.g., tensile and tear strength) of the composite material but does not reinforce the soil on which the geomembrane is placed.

The third production method is known as spread coating. In this method, a geotextile, usually a needle-punched non-woven, is used as a substrate on which the molten polymer is spread into its final thickness.

Geomembrane manufacturing methods are described in more detail in (a.9).
The surface of some geomembranes is roughened or textured, by spraying or embossing, to increase the soil/polymer friction \(a.19\). Three common techniques are coextrusion, lamination and impingement \(a.20\):

- Coextrusion uses a blowing agent in the extrudate which expands on cooling to cause a roughened surface.
- In lamination, a sheet containing a foam is adhered to a conventional sheet. The foaming agent provides a froth that produces a rough, textured laminate stuck to the smooth, solid sheet.
- Impingement is the projection of hot particles on to the smooth sheet.

A review of these texturing techniques and a discussion on characterisation of the surface topography has been presented by Zettler and co-workers \(7\).

### 4.2 Polymers

The vast majority of geomembranes are thin sheets of flexible thermoplastic or thermosetting polymeric materials. The main polymers used are \(a.9\):

**Thermoplastic polymers**

- Polyethylene (PE) – high density (HDPE), medium density (MDPE), linear low density (LLDPE), low density (LDPE), very low density (VLDPE)
- Polypropylene (PP)
- Polyvinyl chloride (PVC)
- Chlorinated polyethylene (CPE)
- Polyamide (PA)

**Thermoset polymers**

- Isoprene-isobutylene (IIR) or butyl rubber
- Epichlorohydrin rubber
- Ethylene-propylene-diene terpolymer (EDPM)
- Polychloroprene (Neoprene)
- Ethylene-propylene terpolymer (EPT)
- Ethylene-vinyl acetate (EVA)
- Ethylene interpolymer alloy (EIA)

**Combination polymers**

- PVC-nitrile rubber
- PE-EPDM
- PVC-EVA
- Crosslinked CPE
- Chlorosulfonated polyethylene (CSPE) ‘Hypalon’

**Others**

- Bitumen impregnated geotextiles
- Elastomer impregnated geotextiles
- Aluminium foil coated geomembranes for protection against hydrocarbons \(329\).

Which geomembrane polymer to choose depends, as usual, on its properties, availability and, of course, on the application and structure in which the geomembrane is to be incorporated. The properties will be discussed in more detail in Section 4.4 (Testing).

No study appears to have been performed which compares the properties of all these polymers as geomembrane sheets. However, *Table 6* \(a.21\) provides a useful qualitative comparison of geomembrane liners made from eight polymers and, another type of geosynthetic barrier known as a geosynthetic clay liner (GCL). The attributes considered are physical properties, durability, installation damage, seaming and cost.

*Table 6* refers to seaming methods, that is to say the techniques used to join together the membrane sheets either at the factory or on site. Production of a leak tight and durable seam is clearly vital otherwise the geomembrane’s function as a fluid barrier is lost. There are several general seaming methods. The choice is governed by the polymer and site requirements.

- Solvent: A liquid solvent is brushed between two sheets of membrane followed by pressure to form the seal.
- Adhesive: A glue dissolved in a solvent is applied by brush or roller to the membrane sheets which are brought together after the surface becomes tacky.
### Table 6 Geomembranes; comparison of polymers

<table>
<thead>
<tr>
<th>Attribute</th>
<th>HDPE</th>
<th>LLDPE</th>
<th>PVC</th>
<th>EPDM</th>
<th>EIA</th>
<th>Reinforced CSPE</th>
<th>Flexible PP</th>
<th>GCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical resistance</td>
<td>Excellent</td>
<td>Good</td>
<td>Fair</td>
<td>Good</td>
<td>Excellent when cured</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Fair</td>
</tr>
<tr>
<td>Hydrocarbon resistance</td>
<td>Good</td>
<td>Good</td>
<td>Fair</td>
<td>Good</td>
<td>Excellent when cured</td>
<td>Good</td>
<td>Good</td>
<td>Poor</td>
</tr>
<tr>
<td>Weathering; UV resistance</td>
<td>Excellent</td>
<td>Fair</td>
<td>Poor</td>
<td>Excellent</td>
<td>Excellent when cured</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Poor</td>
</tr>
<tr>
<td>Thermal stability</td>
<td>Poor</td>
<td>Poor</td>
<td>Good</td>
<td>Excellent</td>
<td>Good – excellent when reinforced</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Tensile properties</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Good – excellent when reinforced</td>
<td>Good</td>
</tr>
<tr>
<td>Elongation; uniaxial</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Good</td>
<td>Good</td>
<td>Fair</td>
<td>Good</td>
<td>Excellent</td>
<td>Fair</td>
</tr>
<tr>
<td>Elongation; multiaxial</td>
<td>Poor</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Good</td>
<td>Fair</td>
<td>Good</td>
<td>Excellent</td>
<td>Fair</td>
</tr>
<tr>
<td>Puncture resistance</td>
<td>Fair</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Good</td>
<td>Excellent</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Stress cracking</td>
<td>Fair</td>
<td>Good</td>
<td>Does not occur</td>
<td>Does not occur</td>
<td>Does not occur</td>
<td>Does not occur</td>
<td>Does not occur</td>
<td>Does not occur</td>
</tr>
<tr>
<td>Resistance to installation damage</td>
<td>Fair</td>
<td>Fair</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Good</td>
<td>Good</td>
<td>Excellent</td>
<td>Good</td>
</tr>
<tr>
<td>Seaming methods</td>
<td>Thermal/excellent</td>
<td>Thermal/excellent</td>
<td>Thermal or solvent bonding/ good</td>
<td>Tape seams/good</td>
<td>Thermal/excellent</td>
<td>Thermal or solvent bonding good</td>
<td>Thermal/excellent</td>
<td>Laps only</td>
</tr>
<tr>
<td>Ease of repair in service</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Poor needs adhesives</td>
<td>Excellent</td>
<td>NA</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Fair</td>
<td>Excellent</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Excellent</td>
<td>NA</td>
</tr>
<tr>
<td>Roll cost</td>
<td>Low</td>
<td>Low/medium</td>
<td>medium</td>
<td>Medium/high</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
</tr>
</tbody>
</table>

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- Thermal: There is a range of thermal methods in which the opposing surfaces are melted by some means such as hot air or electrically heated knife or wedge. The melted surfaces are pressed together by rollers.
- Mechanical: The usual mechanical joining methods are utilisation of sticky tapes or sewing. The sewn seams are subsequently waterproofed.

The solvent and adhesive methods tend to be used for thermoplastic polymers and elastomers such as PVC,
CPE, EDPM, and CSPE. Thermal methods can be employed for most thermoplastic polymers but are especially important for semi-crystalline polyethylene materials like HDPE and LDPE. A more detailed description of geomembrane seaming is given in Chapter 5 of Designing with Geosynthetics by Koerner (a.9).

Some further advantages and disadvantages of specific polymers are now given.

**PVC (polyvinyl chloride)**
- Tough without reinforcement
- Good seams by dielectric, solvent or heat
- Elasticised for flexibility, plasticiser leaches with time

**CPE (chlorinated polyethylene)**
- Seams easy to make by dielectric or solvent
- Plasticised with PVC

**CSPE (chlorosulfonated polyethylene thermoplastic rubber)**
- Good seams by heat or adhesive

**Butyl**
- Poor field seams

**CP (chloroprene/neoprene cured rubber)**
- Low gas permeability
- Fair field seams using solvent and tape

**HDPE**
- Good seams by thermal or extrusion methods
- Low friction surfaces
- High thermal expansion and contraction

**MDPE, LDPE and VLDPE**
- Good seams by thermal or extrusion methods
- Moderate thermal expansion and contraction

**LLDPE**
- High friction surface
- Good seams by thermal or extrusion methods
- Large variation in thickness

Further comparative properties are given in Table 7 which has been generated from information in references a.9 and a.22.

<table>
<thead>
<tr>
<th>Table 7 Geomembrane polymers: advantages and disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factor</strong></td>
</tr>
<tr>
<td>------------</td>
</tr>
<tr>
<td>Cost</td>
</tr>
<tr>
<td>Chemical resistance</td>
</tr>
<tr>
<td>Weathering</td>
</tr>
<tr>
<td>High temperature</td>
</tr>
<tr>
<td>Cold crack</td>
</tr>
<tr>
<td>Stress crack</td>
</tr>
</tbody>
</table>

*CP = chloroprene rubber*
Four of the more common geomembrane polymers are now discussed.

### 4.2.1 Polyethylene

The most common form of polyethylene used for liners, for example landfill, is known as high density polyethylene (HDPE). Strictly, HDPE is a medium density resin made more dense by the addition of carbon black as a UV absorber. HDPE has a high crystallinity which, in part, accounts for its good chemical and UV light resistance.

The longevity of HDPE has been demonstrated by excavating and retesting samples after 20 years exposure to waste water from a steam electric generating station (a.23). The study showed that no significant reduction in physical properties (tensile, tear, puncture) had taken place over this time period. Disadvantages of HDPE are its lack of flexibility, its high coefficient of thermal expansion and its susceptibility to environmental stress cracking (ESC). HDPE geomembrane seams are made by thermal fusion, hot wedge or extrusion fillet welding.

Polyethylene is also known in lower density forms, namely very low density (VLDPE), medium density (MDPE) and linear low density (LLDPE). These low density variants are more flexible and have better ESC performance. However, their low crystallinity means that their chemical resistance is poorer than HDPE.

Polyethylene ozone resistance is superior to many other polymers due to the very low level of unsaturation in the molecular structure. Oxidation resistance is also good in stabilised polyethylene products.

### 4.2.2 Polyvinyl Chloride (PVC)

PVC is normally a brittle and rigid polymer. However, additives can be added to improve processing as well as properties. Typical additives for flexible PVC are:

- Lead salts and organic compounds of barium, calcium and other metals to improve heat and light stability.
- Lubricating additives, such as stearates or palmitates, to improve processability.
- Plasticisers to improve flexibility.

It is the presence and potential mobility of the plasticisers which make PVC susceptible to various chemicals and UV radiation. The latter can cause loss of the plasticiser and a reversion of the PVC to its brittle state. Suitably plasticised PVC is one of the most flexible and workable membranes. PVC geomembrane seams used to be formed, universally, by chemical bonding but more recently thermal fusion welding has been successfully employed.

A comprehensive review of the durability of PVC geosynthetics is given in (244). In this review, PVC chemistry, processing methods, agencies and mechanisms of degradation and an account of earlier studies, are covered in some detail.

### 4.2.3 Chlorosulfonated Polyethylene (CSPE)

In CSPE, also known as Hypalon, hydrogen atoms in the polyethylene backbone are replaced by chlorine and sulfur atoms. This chemical modification results in softening of the geomembrane, which makes the material easier to work and seam. CSPE geomembranes are always scrim reinforced to improve dimensional stability and other mechanical properties. CSPE, when new, can be seamed by solvent bonding or thermal methods. However, it gradually crosslinks or cures with exposure. Once cured the polymer becomes thermoplastic and seaming has to be undertaken using solvent based adhesives.

As Table 6 indicates, CSPE has very good chemical and UV resistance.

### 4.2.4 Polypropylene

Polypropylene, the most popular geotextile polymer, is much less common as a constituent of geomembranes. Polymer catalyst developments have enabled flexible polypropylene (FPP) sheets to be produced by extrusion or calendering. FPP sheets can be both reinforced and unreinforced. Unreinforced polypropylene sheets are very flexible and have high elongation. Unlike HDPE, stress cracking (ESC) is not a problem with FPP which, along with flexibility, probably represents its advantages compared with HDPE. FPP is easy to seam using thermal methods. Its resistance to common chemicals and UV exposure is good provided that the polymer is suitably stabilised.

### 4.2.5 Ethylene Interpolymer Alloy (EIA)

EIA geomembranes are an alloy of PVC with a special ethylene interpolymer (EI) which results in a flexible
plasticiser free material. EIA geomembranes maintain the advantages of PVC but have a high degree of durability and chemical resistance, especially to hydrocarbons and high temperature. EIA is thermoplastic and so can be bonded using conventional thermal welding methods.

Some comparative physical properties of geomembranes, made from various polymers, are shown in Table 8.

These comparative figures show, inter alia:

- The very high rupture strain of the olefinic polymers; FPP, LLDPE and HDPE
- The high strength (stress) of the reinforced materials; FPP-R and EIA-R
- The high thermal expansion of HDPE and the low value for reinforced FPP
- The excellent puncture resistance of FPP

### 4.3 End Uses

Unlike geotextiles, geomembranes really have only one primary function; namely to act as a barrier to fluids (liquids and gases). Geomembranes are, therefore, designed to be impermeable. To all intents and purposes, and certainly compared with other competing materials like clay or GCLs, geomembranes, employed as a barrier, are impermeable to liquids like water. However, because of the microporous nature of the constituent polymer molecules, geomembranes are permeable, to a small degree, to gases such as methane or carbon dioxide.

Geomembranes are employed, as a waterproof or gas proof barrier, in a range of applications in geotechnical structures. Some examples (a.9) of geomembrane usage are:

- As liners for waste liquids, potable waters, solar ponds
- Canal and reservoir liners
- Solid waste landfill liners
- Solid waste landfill covers or caps (210)
- Landfill odour control

<table>
<thead>
<tr>
<th>Property</th>
<th>Method</th>
<th>Units</th>
<th>FPP</th>
<th>LLDPE</th>
<th>HDPE</th>
<th>CSPE-R</th>
<th>EIA-R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rupture strain uniaxial</td>
<td>%</td>
<td></td>
<td>850</td>
<td>800</td>
<td>300</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Rupture strain multiaxial</td>
<td>%</td>
<td></td>
<td>150</td>
<td>150</td>
<td>110</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>Burst stress</td>
<td>MPa</td>
<td></td>
<td>15</td>
<td>15</td>
<td>14</td>
<td>18</td>
<td>35</td>
</tr>
<tr>
<td>Burst strain</td>
<td>%</td>
<td></td>
<td>0.1</td>
<td>0.1</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Coefficient of expansion</td>
<td>cm/cm/°C</td>
<td></td>
<td>12 x 10⁵</td>
<td>12 x 10⁵</td>
<td>7.0</td>
<td>1.8</td>
<td>4.0</td>
</tr>
<tr>
<td>Puncture strength, Cone height</td>
<td>cm</td>
<td></td>
<td>10.0</td>
<td>10.0</td>
<td>7.8</td>
<td>7.8</td>
<td>7.8</td>
</tr>
</tbody>
</table>

- $R = \text{reinforced}$


- Tunnel waterproofing (113)
- Facing of earth and rockfill dams
- Floating reservoir covers to reduce evaporation loss or prevent pollution
- Prevention of gas seepage beneath buildings (e.g., radon and hydrocarbons)
- As a waterproofing layer beneath asphalt overlays
- To form barrier tubes as dams
- Liquid storage (polymer selection important)
- Contaminated land barrier walls (177)

By far the commonest and most important use of geomembranes is in landfill sites as a liner containing waste where its function is to prevent the passage of leachate (liquid formed by interaction of rain water with the waste products) into aquifers and river systems.

4.4 Testing and Properties of Geomembranes

As with geotextiles (Section 3.4), geomembrane tests can be subdivided into various categories; characterisation or identification, physical or mechanical, and durability. The hydraulic category does not yet feature because there are, currently, no full European or international standards for determining the water permeability of geomembranes.

Table 9 lists the important properties of geomembranes, the standard test methods and some appropriate comments.

It will be noticed in Table 9 that most of the standard tests, currently used to characterise and specify geomembranes, are American (ASTM). This is because the American committee on standardisation of geomembranes (D 35) is further advanced than the comparable European (CEN 189) and International committees. Consequently, many ASTM tests have been, and are being, called up in geomembrane specifications and brochures. Most of the European tests are at the draft or provisional stage (prENS). Some of these drafts are included in Table 9.

Brief remarks follow on a few critical tests where the chemical or morphological nature of the constituent polymer has a strong influence on the properties of the geomembrane sheet.

### 4.4.1 Tensile Properties

In the commonest geomembrane tensile test, the specimen, in the shape of a dumbbell or dogbone, 38 mm long and 6.3 mm wide in the narrow central region, is extended to rupture. This is an index test used for quality control, comparison of different variations within one material, comparison of different types of geomembrane and conformance to a specification. For reinforced geomembranes, the dumbbell shape is not suitable and a strip specimen is tested which includes several elements of the reinforcing scrim.

The shape of the stress-strain curves, generated by stretching the material to failure, depends on several factors, of which polymer type and state are the most important. Many non-reinforced membrane materials (PVC, PP) show a gradual increase in stress, with strain, until failure. HDPE, and other polyethylenes, exhibit a pronounced yield point at low extension (10-12%), followed by a slight dip and then a very long elongation to failure (Figure 3). The reason for this yield and long extension behaviour is that polymer molecules in HDPE geomembrane sheets are not oriented, i.e., they are not lined up parallel to the test strain direction. When the molecules are oriented during manufacture, as in yarns or geogrids, the stress-strain curve changes. The yield disappears, stiffness increases and extension at break reduces.

For any one polymer type, the molecular arrangement governs the material properties. The essential factors are:

- Orientation (molecular alignment)
- Molecular weight
- Molecular weight distribution
- Crystallinity
- Degree of crosslinking

For example, increasing the average molecular weight results in an increase in tensile strength, elongation and other mechanical properties such as tensile, puncture and impact strength. Resistance to heat and stress cracking are also improved.

Increasing polymer crystallinity causes an increase in tensile strength, modulus and hardness, but elongation, flexibility, impact strength and stress crack resistance is reduced.
<table>
<thead>
<tr>
<th>Category</th>
<th>Property</th>
<th>Test method</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characterisation</td>
<td>Thickness</td>
<td>ASTM 5199</td>
<td>Nominal thickness of all geosynthetics</td>
</tr>
<tr>
<td></td>
<td>Thickness</td>
<td>ASTM D5994</td>
<td>Core thickness of textured geomembranes</td>
</tr>
<tr>
<td></td>
<td>Thickness</td>
<td>ASTM D1593</td>
<td>PVC specification often used for reinforced geomembranes</td>
</tr>
<tr>
<td></td>
<td>Thickness</td>
<td>ASTM D751</td>
<td>Coated fabric general specification used for smooth geomembranes</td>
</tr>
<tr>
<td></td>
<td>Density (column)</td>
<td>ASTM D1505</td>
<td>Level to which specimen sinks in a liquid column with a density gradient</td>
</tr>
<tr>
<td></td>
<td>Density (displacement)</td>
<td>ASTM D792-9</td>
<td>Determined from weight in water and air</td>
</tr>
<tr>
<td></td>
<td>Carbon black content</td>
<td>ASTM D1603</td>
<td>Carbon black UV absorber. Pyrolysis in nitrogen atmosphere</td>
</tr>
<tr>
<td></td>
<td>Carbon black content</td>
<td>ASTM D4218</td>
<td>Pyrolysis in air using muffle furnace</td>
</tr>
<tr>
<td></td>
<td>Carbon black dispersion</td>
<td>ASTM D3015</td>
<td>Distribution of carbon particles in polymer matrix. Old method using rubber standards</td>
</tr>
<tr>
<td></td>
<td>Carbon black dispersion</td>
<td>ASTM D5596</td>
<td>New method specially for polyolefin geomembranes</td>
</tr>
<tr>
<td></td>
<td>Water absorption</td>
<td>ASTM D570</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Melt flow index</td>
<td>ASTM D1238</td>
<td>Flow rate of plastic extruded through orifice at constant load and temperature</td>
</tr>
<tr>
<td></td>
<td>Dimensional stability</td>
<td>ASTM D1204</td>
<td>To hot air</td>
</tr>
<tr>
<td></td>
<td>Water vapour permeability</td>
<td>ASTM E96</td>
<td>Mass transfer across humidity gradient; indication of porosity</td>
</tr>
<tr>
<td></td>
<td>Water permeability</td>
<td>prEN 14150</td>
<td>(131)</td>
</tr>
<tr>
<td></td>
<td>Gas permeability</td>
<td>ASTM D1434</td>
<td></td>
</tr>
<tr>
<td>Physical/mechanical</td>
<td>Tensile properties (dumbbell)</td>
<td>ASTM D638</td>
<td>Specimen extended to break at constant strain. Strength and extension at yield and break</td>
</tr>
<tr>
<td></td>
<td>Tensile properties (strip)</td>
<td>ASTM D882</td>
<td>For reinforced geomembranes</td>
</tr>
<tr>
<td></td>
<td>Tensile properties</td>
<td>EN ISO 10319</td>
<td>Wide width test adapted from geotextiles (144)</td>
</tr>
<tr>
<td></td>
<td>Tear strength</td>
<td>ASTM D1004</td>
<td>Force to initiate tearing at notch on crescent shaped specimen</td>
</tr>
<tr>
<td></td>
<td>Puncture resistance</td>
<td>FTMS 101C/2065</td>
<td>Tapered probe driven through specimen at constant speed</td>
</tr>
<tr>
<td></td>
<td>Puncture resistance (CBR)</td>
<td>BS EN ISO 12236</td>
<td>50 mm cylinder plunger driven through specimen at constant speed</td>
</tr>
<tr>
<td></td>
<td>Seam strength (shear)</td>
<td>ASTM D4437</td>
<td>Maximum force and mode of failure noted</td>
</tr>
<tr>
<td></td>
<td>Seam strength (peel)</td>
<td>ASTM D413</td>
<td>Maximum force and mode of failure noted</td>
</tr>
</tbody>
</table>
Table 9 Standard tests for geomembranes (Continued)

<table>
<thead>
<tr>
<th>Category</th>
<th>Property</th>
<th>Test method</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Durability</td>
<td>Environmental stress cracking (ESC)</td>
<td>ASTM D5397</td>
<td>Constant stress test, propagation of notch in presence of surfactant</td>
</tr>
<tr>
<td></td>
<td>Oxidative induction time (OIT)</td>
<td>ASTM D3895</td>
<td>Specimen heated in DSC calorimeter. OIT is time from initiation of oxygen to start of decomposition</td>
</tr>
<tr>
<td></td>
<td>UV light (weathering)</td>
<td>ENV 12224</td>
<td>5 hr, UVA light followed by 1 hr water spray for 430 hr</td>
</tr>
<tr>
<td></td>
<td>Oxidation</td>
<td>ENV ISO 13438</td>
<td>Oven test: 100 or 110 °C for 14 to 56 days, depending on polymer</td>
</tr>
<tr>
<td></td>
<td>Liquids</td>
<td>ENV ISO 12960</td>
<td>Screening test: Effect on geomembrane of acid and alkali, 3 days at 60 °C</td>
</tr>
<tr>
<td></td>
<td>Hydrolysis</td>
<td>ENV 12227</td>
<td>Effect of water: 95 °C for 28 days</td>
</tr>
<tr>
<td></td>
<td>Microorganisms</td>
<td>BS EN 12225</td>
<td>Soil burial test: 16 weeks at 26 °C, 95% RH</td>
</tr>
<tr>
<td></td>
<td>Chemical resistance</td>
<td>EPA 9090</td>
<td>Leachate at 23 and 50 °C for 30, 60, 90 and 120 days</td>
</tr>
</tbody>
</table>

Figure 3
Stress-strain curves of geomembranes
4.4.2 Durability

The ability to resist a range of environmental agencies is even more important for geomembranes than geotextiles since they are often in the presence of aggressive materials such as landfill leachates.

One property of particular concern is environmental stress cracking.

4.4.2.1 Environmental Stress Cracking (ESC)

ESC is the failure, by brittle fracture, of plastic materials at stresses well below their ultimate yield tensile stress, in the presence of chemicals such as surfactants. Such premature failure will result in the geomembrane losing its function as an impermeable barrier, i.e., it will leak. Field experience of this problem has been described (297). There are other important papers on ESC (44, 233).

ESC is assessed by the ‘Notched Constant Tensile Load’ test (Table 8) in which a notched dumbbell shaped specimen is placed, under constant load (30% of yield stress), in a surface wetting agent at elevated temperature (50 °C). The time to failure by cracking across the notch is recorded. 200 hours is currently regarded as an acceptable time limit for this test (298, a.24, a.25).

Only crystalline polyethylene polymers suffer from this phenomenon. In general, the higher the crystallinity (as indicated by density) the poorer the ESC performance, i.e., high density polyethylene (HDPE) is especially susceptible to ESC. Manufacturers of these crystalline polyolefin polymers have to make modifications to the chemical structure to reduce their stress cracking tendency to an acceptable level.

A report, explaining the causes and implications of ESC, has been written by Wright (92).

4.4.2.2 Chemical Resistance

The chemical resistance of various geosynthetic polymers is referred to in Section 4.2. There are no final European tests for chemicals at the time of writing, although it is likely that the geotextile tests for liquids (acid/alkali) and the synthetic leachate screening test will be adopted for geomembranes.

The test procedure EPA 9090, devised in the USA by the Environmental Protection Agency (EPA), has been the preferred method for determining whether a polymer is chemically compatible with a landfill leachate. This is a performance test in that the geomembranes are usually immersed in actual leachates from the site rather than to a standard leachate made up in the laboratory. The protocol is quite complex and time consuming. Geomembrane samples are exposed to the leachate at 23 °C and 50 °C for periods of 30, 60, 90 and 120 days. A range of physical tests is then performed on specimens removed after these intervals. The tests include dimensions (thickness, length, width), tensile properties, initial modulus, tear and puncture strength. Graphs are generated of percentage change in the properties versus incubation duration (days). Assessment of the curves requires skill and judgement to decide whether the property-time trends (if detected) are realistic and significant before pronouncing on chemical compatibility, and hence suitability, of the polymer to exposure in a particular leachate.

Many reports and papers have been written on the subject of geomembrane polymer chemical resistance. A selection of interesting and relevant references from the Rapra Polymer Library is now given:

- Comparison of PVC with other geomembranes (48)
- Chemical compatibility of LLDPE to organic fluids (50)
- Effect of a range of organic compounds on HDPE, LLDPE, VLDPE and PP geomembranes (57, 58, 59, 60)
- Chemical tests on HDPE (77)
- Chemical resistivity of VLDPE (84)
- Durability of polyethylene based geomembranes to aggressive liquids (86)
- Permeation of organic compounds through HDPE (115)
- Diffusion of aromatic liquids through HDPE, LLDPE, VLDPE, and PP geomembranes (121)
- A review of durability considerations for PVC in geosynthetics applications (244)

4.4.2.3 UV Radiation

The general comments on UV/weathering testing of geotextiles apply equally to geomembranes. Carbon
black is again added to the polymer to absorb UV radiation. Horrocks and co-workers have written authoritative articles on the effect of carbon black on the thermal and photo-oxidative degradation of polyolefins (54, 227). Other compounds like hindered amine light stabilisers (HALS) are also very effective UV and thermal stabilisers (96).

5 Geosynthetic Clay Liners (GCLs)

5.1 Description and Manufacturing

Geosynthetic clay liners (GCLs) are members of the geosynthetic family of products. They are essentially prefabricated bentonite clay blankets used as water barriers. The first GCL was invented by James Clem in 1980 and later manufactured by Clem Environmental Corp. in Fairmont, Georgia. There are two basic types of GCL:

- Bentonite sandwiched between two geotextiles (Type A)
- Bentonite glued to a geomembrane (Type B)

The main Type A product consists of bentonite sandwiched between a woven and a non-woven needle punched geotextile. The bentonite is mechanically bonded by needle punching fibres from the non-woven geotextile, through the bentonite to the other woven geotextile. Commercial GCLs made by this method include Bentofix and Bentomat.

In other Type A products, bentonite is mixed with adhesive and held between two woven geotextiles. Additional support for the clay component is provided by stitch bonding in which the structure is held together by stitches sewn at intervals across the width or along the length of the GCL.

5.2 Polymers and Constituent Materials

As explained in Section 5.1, the main constituent of GCLs is not a polymer (synthetic or natural) but a clay mineral called bentonite. Bentonite is the name of the clay material originally mined in the Fort Benton formation of Rock Creek, Wyoming. Bentonite is a mixture of minerals composed mainly (60 to 90%) of montmorillonite, the least permeable of all the clay minerals. It is a highly colloidal smectic material formed from volcanic ash originally deposited in ancient lakes, estuaries or ocean basins. Chemically, montmorillonite is a hydrous aluminium silicate with a structural sandwich of one ionic sheet of aluminium and hydroxyl between two silicate (Si₄O₁₀)₄ sheets, i.e., sandwiches piled on top of each other with water between and nothing but weak bonds to hold them together. As a result of this structure, additional water can readily enter the lattice and cause the mineral to swell appreciably, thus further weakening the attraction between the layers.

Chemicals are often added to the bentonite (e.g., soda ash or polymers) to improve its swelling and water absorbency.

Bentonite absorbs very large amounts of water and swells to many times its original volume when hydrated. When bentonite is confined and hydrated, this property creates a uniform, low permeability (hydraulic conductivity, 10⁻¹² to 10⁻¹⁰ m/s) clay seal with self-healing characteristics.

Sodium and calcium bentonite are the two common forms of this material. Sodium bentonite has a higher water absorbency, swells more and thus has a lower hydraulic conductivity than the calcium form. For example, the free swell values of these materials (a.27) are:

- sodium bentonite 1400-1600%
- calcium bentonite 125%

The other components of GCLs are, as indicated earlier, the covering geotextiles; woven and non-woven. The constituent polymer of these geotextile layers is nearly always polypropylene (see Section 3.2.2).

5.3 End Uses

GCLs, like geomembranes, have but one function which is to act as a barrier to fluids, notably water. They are often used either as a substitute for geomembranes or as an additional layer in conjunction with geomembranes, i.e., a second line of defence.

GCLs are suitable for various lining applications:

- Landfill liners (their most common outlet)
- Landfill covers
- Liquid containment; reservoirs, canals, fly ash lagoons, lakes and ponds
- Secondary containment, e.g., around fuel storage tanks
- Animal waste containment
- Lining heap leach mining facilities
- Earthen dam cores

5.4 Testing and Properties of GCLs

In some GCL standard methods, the whole composite sandwich is tested. In others, tests are performed on the bentonite component only.

Table 10 lists the most commonly specified GCL standard test methods (composite and bentonite).

A useful book is available called ‘Testing and Acceptance Criteria for Geosynthetic Clay Liners’ which summarises available products, provides guidance on many vital GCL tests, gives insight into applications and makes suggestions for specifications (a.26).

5.4.1 Hydraulic Conductivity

As the primary function of GCLs is to prevent, or greatly reduce the passage of water, it is no surprise that the most important test for these materials is water permeability or hydraulic conductivity. This test is carried out in a flexible wall permeameter of the type used for soil permeability determination. The rate of flow of deaired and deionised water, through hydrated GCL, is measured at constant confining pressure and pressure gradient. The two tests, listed in Table 10, operate at different pressure conditions and report different quantities. ASTM D5084 calculates hydraulic conductivity (a specific unit) from the flow value. This term takes into account thickness and hydraulic gradient across the sample. The much simpler ASTM D5887 test determines only the flux which is simply the volume flow through the sample in m³/m²/s. The flux, then, is dependent on the thickness, and hydraulic gradient across, the GCL specimen.

Hydraulic conductivity depends on leachate composition as well as bentonite type and quality.

5.4.2 Friction

Hydrated bentonite has a very low shear strength (effective cohesion of 4-8 kPa, internal friction angle 8-9 degrees) and could fail if laid on slopes unless reinforced by needle punched fibres or some other strengthening method. Needle punching improves the cohesion to 30 kPa and the internal friction angle to about 25 degrees. Work on the shear behaviour of reinforced (130) and unreinforced (106) GCLs has been performed by Eid and Stark. Apart from measuring friction by direct shear, some indication of the internal strength of the GCL can be obtained from peel tests.

6 Geogrids

6.1 Description and Manufacturing

According to ASTM (committee D35 geosynthetics) a geogrid is defined as follows:

A geosynthetic used for reinforcement which is formed by a regular network of tensile elements which has apertures of sufficient size to allow strike-through of surrounding soil, rock or other geotechnical material.

A simpler descriptive definition is provided by the Geosynthetic Research Institute (GRI):

Stiff or flexible polymer grid-like sheets with large apertures used primarily as reinforcement of unstable soils and waste masses.

As the definitions infer, the key feature of a geogrid is the openings between the longitudinal and transverse ribs, known as the apertures, which are typically 1 to 10 cm between the ribs.

Geogrids can be either uniaxial or biaxial. Uniaxial geogrids are designed to be stressed in one direction. The ribs of uniaxial grids tend to be thick and have long, narrow slit like apertures. Biaxial grids can take stresses in both directions. The apertures of biaxial grids are near square or oblong rather than slit shaped. This form of geogrid is manufactured in the following manner.

Holes are punched, in a regular pattern, into a sheet of heavy duty polyethylene or polypropylene. The sheet is then drawn or stretched uniaxially or biaxially. Drawing is carried out under controlled temperature and strain rate, or draw ratio, to allow free flow of the molecules into an elongated or oriented state. Companies manufacturing this type of geogrid include Tensar Corp. and Tenax Corp.
## Table 10 Standard tests for GCLs

<table>
<thead>
<tr>
<th>Category</th>
<th>Property</th>
<th>Test method</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Acceptance testing requirements</td>
<td>ASTM D6495</td>
<td>Guide</td>
</tr>
<tr>
<td></td>
<td>Quality control</td>
<td>ASTM D5889</td>
<td>Standard practice</td>
</tr>
<tr>
<td></td>
<td>Storage and handling</td>
<td>ASTM D5888</td>
<td>Guide</td>
</tr>
<tr>
<td></td>
<td>Sampling</td>
<td>ASTM D6072</td>
<td>Guide</td>
</tr>
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<td></td>
<td>Installation</td>
<td>ASTM D6102</td>
<td>Guide</td>
</tr>
<tr>
<td>Bentonite</td>
<td>Free swell index</td>
<td>ASTM D5890</td>
<td>Index test related to permeability</td>
</tr>
<tr>
<td></td>
<td>Free swell index</td>
<td>USP-NFXVII</td>
<td>Swell volume of 2 g of bentonite in 100 ml of water</td>
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<td></td>
<td>Confined swell index</td>
<td>GRI GCL-1</td>
<td>Degree of swell under load</td>
</tr>
<tr>
<td></td>
<td>Moisture content</td>
<td>ASTM D2216</td>
<td>Oven method</td>
</tr>
<tr>
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<td>Methylene blue titration</td>
<td>API RP131</td>
<td>Cation exchange indicates amount of active bentonite</td>
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<td></td>
<td>Montmorillonite content</td>
<td>X-ray diffraction</td>
<td></td>
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<tr>
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<td>Water absorption</td>
<td>ASTM E946</td>
<td>Water absorption of bentonite via saturated porous plate</td>
</tr>
<tr>
<td></td>
<td>Bentonite content</td>
<td>No standard method</td>
<td>X-ray diffraction; spacing between planes of atoms</td>
</tr>
<tr>
<td></td>
<td>Chemical resistance</td>
<td>ASTM D6141</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fluid loss</td>
<td>ASTM D5891</td>
<td></td>
</tr>
<tr>
<td>Characterisation</td>
<td>Mass per unit area</td>
<td>ASTM D5993</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mass per unit area</td>
<td>ASTM D5261</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thickness</td>
<td>ASTM D5199</td>
<td></td>
</tr>
<tr>
<td>Mechanical</td>
<td>Tensile strength (wide width)</td>
<td>ASTM D4595</td>
<td>Similar to geotextile test</td>
</tr>
<tr>
<td></td>
<td>Tensile strength (wide width)</td>
<td>BS EN ISO 10319</td>
<td>Similar to geotextile test</td>
</tr>
<tr>
<td></td>
<td>Tensile strength (grab)</td>
<td>ASTM D4632</td>
<td>Similar to geotextile test</td>
</tr>
<tr>
<td></td>
<td>Puncture strength (CBR)</td>
<td>BS EN ISO 12236</td>
<td>Similar to geotextile test</td>
</tr>
<tr>
<td></td>
<td>Puncture strength (bevelled probe)</td>
<td>ASTM D4833</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Peel strength</td>
<td>ASTM D413 (Modified)</td>
<td>Indicator of internal shear strength</td>
</tr>
<tr>
<td></td>
<td>Friction</td>
<td>ASTM D6243</td>
<td>Internal and interface shear resistance</td>
</tr>
<tr>
<td></td>
<td>Friction</td>
<td>prEN ISO 12957-1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Resistance to leaching</td>
<td>Draft EN 14415</td>
<td>Hot water, alkaline liquids and organic alcohols</td>
</tr>
</tbody>
</table>
Other forms of geogrid are:

- High tenacity polyester strips ultrasonically bonded at their junctions (Signode Geogrids)
- Polyester filaments bundled together and enclosed within a polyethylene sheath. Junctions are formed by melt bonding the polypropylene at the rib intersections (Paragrids, Linear Composites Ltd.)
- Polyester yarns, woven in an open structure, with the junctions knitted together to link the transverse and longitudinal ribs and coated with latex (Mirafi and Nicolon).

### 6.2 Polymers

The constituent polymers, of those geogrids made from precursor sheets, are polypropylene for biaxial and polyethylene (HDPE) for uniaxial grids. Orientation of the molecular chains by careful drawing of the punctured sheet produces a very strong, high modulus, low creep material ideal for reinforcement applications. Properties of the geogrid can be varied by altering the draw ratio or by changing the molecular weight and degree of crosslinking of the polymer. Information on description, specification data and design techniques for commercially available oriented geogrids (Tensar) is given in references (397, 398, 399).

Bicomponent grids employ high tenacity polyester as the load bearing element, either in the form of a bundle of continuous filaments enclosed within a polypropylene sheath or a woven/knitted structure coated, usually, with PVC. The sheath or coating has a superior chemical resistance to the polyester core and thus protects it from aggressive environmental conditions. For example, polyester is susceptible to hydrolysis in an alkaline (high pH) environment and thus requires outer layer protection in such conditions.

Duvall has studied four coated polyester geogrids with respect to the effect of coating type, thickness, etc., and fibre diameter and distribution (241).

### 6.3 End Uses

Geogrids, with their properties of strength, stiffness and low creep are almost invariably involved in some form of reinforcement. Some examples (a.9) of their reinforcing applications are:

- Beneath aggregate in unpaved roads
- Beneath ballast in railway construction
- Reinforcement of embankments and earth dams
- Repairing slopes and landslides
- As gabions for wall construction, erosion control and bridge abutments
- Construction of mattresses over soft soil, peat and tundra
- As sheet anchors for retaining wall panels
• Asphalt reinforcement in roads
• As inserts between geotextiles and geomembranes
• Bridging mining voids (127)

A detailed description of design methods for geogrids in several of these applications, is given in the book titled ‘Designing for Geosynthetics’ by R.M. Koerner (a.9).

Another useful general review of the uses of high strength oriented HDPE and PP geogrids is by Carter and Dixon (197).

6.4 Testing and Properties of Geogrids

Many of the tests for other geosynthetics are also useful for geogrids. These tests are included, along with those directly relevant to geogrids, in Table 11.

The chemistry and structure of the geogrid polymers profoundly influences their properties. As explained earlier, the high strength and stiffness of the single component uniaxial and biaxial grids result from the oriented state of the polyolefin molecules, generated during manufacture.

Molecular orientation also results in a much lower long-term deformation under load (creep) than would be the case with unoriented polyolefin molecules, e.g., as in geomembranes.

Alignment of, and absence of low modulus crimp in, the bundle of polyester strands gives the bicomponent coated grids their excellent tensile characteristics.

The two common types of geogrid, being made of HDPE or protected polyester, have very good chemical and biological resistance in typical ground conditions (a.27).

In common with other geosynthetics, geogrids (especially made from polyolefins) can be degraded by UV exposure. As usual, the addition of 2 to 2.5% carbon black effectively retards the decomposition process (a.27). However, to be safe, geogrids are not usually exposed for more than two weeks before burial by soil.

![Table 11 Standard tests for geogrids](image)

<table>
<thead>
<tr>
<th>Category</th>
<th>Property</th>
<th>Test method</th>
<th>Comments/References</th>
</tr>
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<tbody>
<tr>
<td>Identification</td>
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</tr>
<tr>
<td></td>
<td>Junction type</td>
<td>No standard test</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Open area</td>
<td>No standard test</td>
<td></td>
</tr>
<tr>
<td>Mechanical</td>
<td>Flexural rigidity</td>
<td>ASTM D1388</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tensile strength</td>
<td>EN ISO 10319</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shear strength (friction)</td>
<td>EN ISO 12957-1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pull out strength</td>
<td>No standard test</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Junction (node) strength</td>
<td>GRI TM GG2</td>
<td></td>
</tr>
<tr>
<td>Durability</td>
<td>Tensile creep</td>
<td>EN ISO 13431</td>
<td>(9, 26, 65, 104)</td>
</tr>
<tr>
<td></td>
<td>Installation damage</td>
<td>ENV ISO 10722-1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Environmental stress cracking (ESC)</td>
<td>ASTM D5397</td>
<td>(363, a.27)</td>
</tr>
<tr>
<td></td>
<td>Oxidation</td>
<td>EN ISO 13438</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chemicals</td>
<td>BS EN 14030</td>
<td>Effect of acid and alkali</td>
</tr>
<tr>
<td></td>
<td>UV (weathering)</td>
<td>EN 12224</td>
<td></td>
</tr>
</tbody>
</table>
7 Geocomposites

The term ‘geocomposites’ refers to those synthetic sheet like materials (geosynthetics) which consist of more than one component. The most common subcategories of geocomposites are geonets and other drainage products.

7.1 Geonets

Geonets are grid like materials but used for their in plane drainage capability, whereas geogrids have only a reinforcing function. Geonets, and other in plane drainage composites, consist of a core with a geotextile, or more rarely a geomembrane, fixed to its upper and lower surfaces. The thin, low flow cores (5-7 mm thick) often have diamond shaped apertures; typically 12 mm long by 8 mm wide.

Almost all geonets are made of medium to high density polyethylene (0.935-0.942 g/cm³). Carbon black (1-2%) is added for protection against UV radiation and 0.5 to 1.0% of other additives as processing aids.

The grid like cores of geonets are made by melting and extruding the mixed ingredients into a die with slotted counter-rotating segments where the melt flows at angles forming discrete ribs in two planes. As pressure forces the mass forward, it is pushed over an increasing diameter mandrel, which forces the ribs apart and opens the net, forming the diamond shaped holes. When the net has cooled completely, it achieves its full diameter (60 to 90 cm). It is then cut along its axis and formed into rolls. One way of increasing the thickness, and hence drainage capacity, of the core is to add a foaming agent to the ingredients. which, on heating, forms microspheres in the solidified polymer. Net cores, up to 13 mm thick, can be made by this method.

Apart from the net configuration, drainage cores can have other structures and shapes. Thicker cores (up to 40 mm) are formed from plastic sheets which can be extruded and deformed in such a way as to allow very large quantities of water to flow within the plane of the structure. The supporting elements of this core structure can be pillars or cusps, similar to those in an egg box. As with the thinner geonets, the cores of these drainage geocomposites are covered, on one or both sides, by geotextiles acting as filters. These thicker, high capacity, cores are usually made of polyethylene or polystyrene.

Other drainage variants include strip and wick drains where the polymer is often fluted, for ease of conducting water, formed about 100 mm wide and covered with a geotextile stocking.

Other forms of core consist of stiff nylon filament mats (like a pan scrubber) and Styrofoam balls glued together.

7.1.1 End Uses of Geonets

Geonets are a single function geosynthetic. They are used, almost exclusively, for their in plane drainage (transmissivity) capability.

Examples (a.9) of end use applications for geonets and geocomposite drains are:

- Replacing sand drains for consolidating fine grained, saturated soils
- Water drainage behind retaining walls
- Water drainage beneath sports fields
- Water drainage beneath building foundations
- Leachate drainage of landfill side slopes
- Leachate drainage above landfill liners
- Surface water drainage of landfill caps

7.1.2 Testing and Properties of Geonets

Table 12 shows the most important tests for geonets and other drainage geocomposites.

7.1.2.1 In Plane Flow

Clearly the paramount property of these drainage geocomposites is their capacity to conduct water in the plane, i.e., between the core elements: net ribs, cusps, pillars etc. This property is determined by measuring the water flow, in the plane of the core, under specified conditions of hydraulic gradient and normal pressure (at right angles to the plane).

The geotextile, on either side of the core, can intrude between the core elements and, in some cases,
dramatically reduce the flow. It is, therefore, important to select stiff, creep resistant geotextiles. This core intrusion propensity is taken into account in the test by inserting soft foam rubber layers, to simulate soil, on either side of the geonet. With low modulus or creep prone geotextiles, the foam will push between the core elements, under pressure, and cause a flow reduction.

Reference a.28 contains an article for designers on geotextiles in drainage systems.

### 7.1.2.2 Compressive Strength

There is a strong interaction between in plane flow and compressive strength; the more the core compresses the lower the resultant flow will be. This reduction in thickness is influenced by both the core structure and the polymer properties. Crystalline polyethylene, of medium to high density, is used to provide good compression yielding resistance compared with other polymers. The standard European test for compressive strength measures the stress required to compress a 10 x 10 cm specimen of core, at a strain rate of 2% per minute, by 10% or to cause collapse of the core components, if appropriate.

#### 7.1.2.3 Compressive Creep

The major endurance property of concern with drainage cores is the long-term sustained deformation of the structure, under pressure which would gradually cause decreasing flow rates. This phenomenon is known as compressive creep and is affected by the design of the core elements and polymer composition.

<table>
<thead>
<tr>
<th>Category</th>
<th>Property</th>
<th>Number</th>
<th>Comments / References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characterisation</td>
<td>Thickness</td>
<td>EN 964-1</td>
<td>At 2, 20 and 200 kPa, indicates compressibility</td>
</tr>
<tr>
<td></td>
<td>Thickness</td>
<td>ASTM D5199</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mass per unit area</td>
<td>EN 965</td>
<td></td>
</tr>
<tr>
<td>Mechanical</td>
<td>Tensile properties</td>
<td>EN ISO 10319</td>
<td>Wide width sample (20 cm) stretched at 20%/min to failure</td>
</tr>
<tr>
<td></td>
<td>Friction (direct shear)</td>
<td>prEN ISO 12957-1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Installation damage</td>
<td>ENV ISO 10722-1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Compressive strength</td>
<td>ASTM D1621</td>
<td>Force to reduce thickness by 10%</td>
</tr>
<tr>
<td>Hydraulic</td>
<td>Water flow (in plane)</td>
<td>EN ISO 12958</td>
<td>Transmissivity (82)</td>
</tr>
<tr>
<td></td>
<td>Water flow (in plane)</td>
<td>BS 6906: Pt 7</td>
<td></td>
</tr>
<tr>
<td>Durability</td>
<td>Durability criteria test</td>
<td>BS EN 12226</td>
<td>Tensile strength of composite or components</td>
</tr>
<tr>
<td></td>
<td>Compressive creep</td>
<td>EN 1897</td>
<td>Compressive and shear strain after 1000 hr under specified pressures</td>
</tr>
<tr>
<td></td>
<td>Abrasion</td>
<td>EN ISO 13427</td>
<td>Standard geotextile test</td>
</tr>
<tr>
<td></td>
<td>UV light (weathering)</td>
<td>ENV 12224</td>
<td>Standard geotextile test</td>
</tr>
<tr>
<td></td>
<td>Oxidation</td>
<td>ENV ISO 13438</td>
<td>Standard geotextile test</td>
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<td></td>
<td>Liquids</td>
<td>ENV ISO 12960</td>
<td>Standard geotextile test</td>
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<td></td>
<td>Hydrolysis</td>
<td>ENV 12227</td>
<td>Polyester components only</td>
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<tr>
<td></td>
<td>Microorganisms</td>
<td>BS EN 12225</td>
<td>Soil burial test</td>
</tr>
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</table>

Table 12 Standard tests for geonets
7.1.2.4 Other Tests

The above three tests (water flow, compression and creep) are those specific to drainage composite. Other physical properties (e.g., tensile strength, friction) and durability characteristics (chemical and UV resistance etc.) are performed using the standard tests for geotextiles shown in Table 4.

7.2 Other Geocomposites

Apart from the drainage geocomposites, described above, there are other composite, multi-component products which can carry the prefix ‘geo’ (a.9).

7.2.1 Geotextile-Geomembrane Composites

Geotextiles can be laminated on one or both sides of a geomembrane for a number of reasons. As a reinforcer, where the geotextile gives increased resistance to puncture, tear propagation and friction as well as providing additional tensile strength. When the laminated geotextile is a needle punched non-woven type, it can act as a drainage route, conducting water or leachate away from the geomembrane.

7.2.2 Geomembrane-Geogrid Composites

Geomembranes and geogrids made from the same material, e.g., HDPE, can be welded together to form an impermeable barrier with enhanced strength and friction properties.

Geogrids can also be combined with geotextiles to produce a material with the handling and installation benefits of a geotextile and the strength of a geogrid (186).

7.2.3 Geocells

Rigid polymer strips can be arranged vertically in a box like fashion and filled with soil. The product, thus, forms a cellular structure and, acting with the contained soil, can make a strong and stable mattress. Geocells have been used to make large earth embankments and to repair crumbling bridge decking and abutments (a.29).

7.2.4 Geotextile-Steel Composites

Steel strands can be woven within a geotextile matrix to give a very high strength product which can sustain, when used as a substrate, extremely large loads, e.g., to support buildings.

7.2.5 Geotextile-Bead Composites

Styrofoam beads can be sandwiched between geotextiles (as filters) and geomembranes (as vapour barriers) for drainage products behind basement walls. The Styrofoam acts as a drain and an insulator.

7.2.6 Polymeric Fibres

Staple polymeric fibres, mixed with soil, is a form of in situ composite which can reinforce soil embankments (125, 279).

7.2.7 Geofoam

Geofoam is made of expanded polystyrene (EPS). It has been used in civil engineering as a light weight fill under a road sub-grade, built over a low load bearing soil. Geofoam has also found application for vibration damping, gas venting and soil stabilisation (173, 191, 236, a.30).

7.2.8 Polyurethane/Geotextile Composites

A polyurethane/geotextile composite has been developed which has been used to line deteriorated concrete and earthen ditches (a.31). This liner consists of two layers of geotextile embedded in a solid, flexible matrix of polyurethane. This composite has the advantages of liners made from other polymers of good adhesion, easy repair and high resistance to mechanical damage.

Additional References


a.2 G. Richardson, Geotechnical Fabrics Report, 2002, 20, 6, 10.
a.8 Geosynthetics, Freedonia Group Inc., West Hartford, USA, December 2002.
a.27 N.E. Wrigley, Materials Science and Technology, 1987, 3, 161.
a.29 Geotechnical Fabrics Report, 2002, 20, 8, 32.
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
<th>Additional Notes</th>
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<tr>
<td>ASTM</td>
<td>American Society for Testing and Materials</td>
<td></td>
</tr>
<tr>
<td>BS</td>
<td>British Standards</td>
<td></td>
</tr>
<tr>
<td>CBR</td>
<td>California bearing ratio</td>
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</tr>
<tr>
<td>CP</td>
<td>chloroprene</td>
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</tr>
<tr>
<td>CPD</td>
<td>Construction Products Directive</td>
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</tr>
<tr>
<td>CPE</td>
<td>chlorinated polyethylene</td>
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<tr>
<td>CSPE</td>
<td>chlorosulfonated polyethylene</td>
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</tr>
<tr>
<td>DSC</td>
<td>differential scanning calorimetry</td>
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</tr>
<tr>
<td>EDPM</td>
<td>ethylene-propylene-diene terpolymer</td>
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</tr>
<tr>
<td>EIA</td>
<td>ethylene interpolymer alloy</td>
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<tr>
<td>EN</td>
<td>euronorm</td>
<td></td>
</tr>
<tr>
<td>EPA</td>
<td>Environmental Protection Agency</td>
<td></td>
</tr>
<tr>
<td>EPS</td>
<td>expanded polystyrene</td>
<td></td>
</tr>
<tr>
<td>EPT</td>
<td>ethylene-propylene terpolymer</td>
<td></td>
</tr>
<tr>
<td>ESC</td>
<td>environmental stress cracking</td>
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<tr>
<td>EVA</td>
<td>ethylene-vinyl acetate</td>
<td></td>
</tr>
<tr>
<td>FPP</td>
<td>flexible polypropylene</td>
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<tr>
<td>GCL</td>
<td>geosynthetic clay liner</td>
<td></td>
</tr>
<tr>
<td>GFR</td>
<td>Geotechnical Fabrics Report</td>
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</tr>
<tr>
<td>GRI</td>
<td>Geosynthetic Research Institute</td>
<td></td>
</tr>
<tr>
<td>HALS</td>
<td>hindered amine light stabilisers</td>
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</tr>
<tr>
<td>HDPE</td>
<td>high density polyethylene</td>
<td></td>
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<tr>
<td>IFAI</td>
<td>Industrial Fabrics Association International</td>
<td></td>
</tr>
<tr>
<td>IGS</td>
<td>International Geosynthetics Society</td>
<td></td>
</tr>
<tr>
<td>IIR</td>
<td>isoprene-isobutylene or butyl rubber</td>
<td></td>
</tr>
<tr>
<td>ISO</td>
<td>International Standards Organization</td>
<td></td>
</tr>
<tr>
<td>LDPE</td>
<td>low density polyethylene</td>
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</tr>
<tr>
<td>LLDPE</td>
<td>linear low density polyethylene</td>
<td></td>
</tr>
<tr>
<td>MDPE</td>
<td>medium density polyethylene</td>
<td></td>
</tr>
<tr>
<td>OIT</td>
<td>oxidative induction time</td>
<td></td>
</tr>
<tr>
<td>PA</td>
<td>polyamide</td>
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<td>PE</td>
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</tr>
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<td>PET</td>
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</tr>
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<td>PP</td>
<td>polypropylene</td>
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<td>prEN</td>
<td>provisional euronorm, i.e., draft European Standard</td>
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<tr>
<td>PVC</td>
<td>polyvinyl chloride</td>
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<tr>
<td>-R</td>
<td>reinforced</td>
<td></td>
</tr>
<tr>
<td>RH</td>
<td>relative humidity</td>
<td></td>
</tr>
<tr>
<td>UV</td>
<td>ultraviolet</td>
<td></td>
</tr>
<tr>
<td>VLDPE</td>
<td>very low density polyethylene</td>
<td></td>
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</table>
Abstracts from the Polymer Library Database

Item 1
*Advanced Materials & Processes*
160, No.11, Nov.2002, p.6
**POLYMERIC PRODUCTS PERFORM HERCULEAN TASKS**

In August, Eastman Chemical signed an agreement with Geocell Systems to be the exclusive supplier of copolyester materials used in Geocell’s Rapid Deployment Flood Wall (RDFW). RDFW is said to be a faster, less expensive and less labour intensive alternative to sandbags. It is based on an expandable, stackable, modular wall made of an ‘environmentally responsible’ plastic that can be filled with sand or other locally available fill material. In addition to flood control, the technology also has military applications. RDFW is the result of cooperative R&D between Geocell and the US Army Corps of Engineers. Details are given.

EASTMAN CHEMICAL CO.; GEOCELL SYSTEMS INC.
USA
Accession no.877527

Item 2
*Polymer Degradation and Stability*
79, No.1, 2003, p.161-72
**OXIDATIVE RESISTANCE OF HIGH-DENSITY POLYETHYLENE GEOMEMBRANES**
Mueller W; Jakob I
BAM

The results are reported of long-term oven ageing and water immersion tests carried out on various HDPE geomembranes for use as landfill liners. All the resins were stabilised with phenolic and phosphate antioxidants. The mechanical properties and oxidative induction times of the liners were monitored during testing and ageing behaviour in hot air was compared with that in hot water. The data obtained indicated that the service life of the liners was dependent upon migration of stabilisers from the liners. 19 refs.

EUROPEAN COMMUNITY; EUROPEAN UNION; GERMANY; WESTERN EUROPE
Accession no.875392

Item 3
*Nonwovens Industry*
33, No.11, Nov.2002, p.26
**GEOTEXTILE MARKET IN JAPAN**
Ohmura K
Osaka Chemical Marketing Center

The demand for non-wovens in the Japanese geotextiles market was estimated at 55 million square metres last year. Demand increased significantly during the second half of the 1990s due primarily to a change in the seepage control method in final disposal. Before 1995, only a sheet of geomembrane was required to prevent seepage, but since then, this single sheet has been replaced by a double liner geomembrane. This method comprises three protection sheets and two sheets of geomembrane in an alternately layered five-layer structure. Spunbonded non-wovens are used in many areas because of their high strength, with the largest end use area being civil engineering.

JAPAN
Accession no.871672

Item 4
*Plastics News(USA)*
**FLOOD WALL NO SANDBAGGER**
Lauzon M

Copolyester sheet can cut costs and installation time associated with flood containment compared to sandbags, according to the developer of the Rapid Deployment flood wall. Geocell Systems says that using the wall makes the time-consuming task of filling and stacking sandbags unnecessary. Other uses include military and civilian protection according to Eastman Chemical, a supplier of copolyester resin used to make sheet for the flood wall. The flood wall is an expandable, stackable, modular wall filled with sand or other locally available materials. Eastman says that it can be constructed in 5% of the time and with 20% of the labour of a comparable sandbag wall. The flood wall also has a range of potential military uses. Very brief details are noted.

GEOCELL SYSTEMS INC.
USA
Accession no.869677

Item 5
*Plastics Technology*
48, No.7, July 2002, p.21
**HDPE FOR TEXTURED GEOMEMBRANE SHEET**

“Fortiflex G36-10-150” is a new fractional-melt HDPE geomembrane resin designed specifically for the textured blown sheet process. It is a hexene copolymer and it comes from Houston-based Solvay Polyethylene North America. Brief details are presented in this small item.

SOLVAY POLYETHYLENE NORTH AMERICA; NORTH AMERICA; USA
Accession no.864690
Item 6
(Waltham, Ma.), 2001, pp.8. 30cms. 25/4/02
MASTERBATCHES FOR GEOMEMBRANES AND GEOTEXTILES
Cabot Plastics
This paper presents an overview of the use of geomembranes and geotextiles in environmental engineering, geotechnical applications and water containment. These polymeric materials can perform many functions, such as sealing, filtration, drainage, reinforcement and protection. Definitions are supplied for the terms geotextile, geogrid, geomembrane and landfill liner, and descriptions given of their typical features and applications. Information is also presented on the use of Cabot masterbatches in such materials, where their role is to provide optimum UV and thermal protection. A selection guide lists suitable geosynthetic applications for several Cabot grades and notes their key characteristics. Properties data are also tabulated for the Plasblak masterbatch range.
USA
Accession no.863796

Item 7
Geosynthetics International
9, No.1, 2002, p.21-40
STRAIN INDUCED CHANGES IN GEOMEMBRANE SURFACE TOPOGRAPHY
Frost J D; Zettler T E; DeJong J T; Lee S W; Kagbo S
Georgia,Institute of Technology; GeoSyntec Consultants; Massachusetts,University; Korea,Institute of Construction Technology
A brief review is presented of geomembrane manufacturing, texturing techniques and characterisation of geomembrane surface topography followed by a discussion on the expected changes in surface topography of the geomembranes in terms of surface roughness parameters measured in the testing programme. Finally, the findings of tests carried out to determine the effect of strain on the surface topography of several geomembranes (smooth, coextruded, impingement and laminated geomembranes) subjected to increasing uniaxial strain levels ranging from 1 to 25% are presented and discussed. 18 refs.
KOREA; USA
Accession no.862477

Item 8
Geosynthetics International
9, No.1, 2002, p.1-19
INFLUENCE OF STRAIN RATE ON THE LOAD-STRAIN CHARACTERISTICS OF GEOSYNTHETICS
Sawicki A; Kazimierowicz-Frankowska K
Poland,Institute of Hydro-Engineering
The results are reported of a study of the effect of strain rate on the load-strain characteristics of various geosynthetics subjected, in particular, to complex loading histories. Geosynthetics tested were a PP, needle-punched geotextile reinforced with a PE geonet, non-woven, stitched or needle-punched PP/polyester geotextiles, a woven polyamide geotextile and a PE geogrid. The isotach properties of geosynthetics and the modelling thereof are discussed and a simple method of describing these properties is proposed. 12 refs.
EASTERN EUROPE; POLAND
Accession no.862477

Item 9
Polymer Testing
21, No.5, 2002, p.489-95
ASSESSMENT OF LONG-TERM PERFORMANCES OF POLYESTER GEOGRIDS BY ACCELERATED CREEP TEST
Jeon H Y; Kim S H; Yo H K
Chonnam,National University; Hanyang,University
Details are given of the use of accelerated creep tests of polyester fabric geogrids to predict long-term creep behaviour. The tests used to time-temperature superposition principle. Creep tests were performed to calculate the partial factor of safety during the service time of the polyester geogrids. The tests were performed at various temperatures and loading levels. 11 refs.
KOREA
Accession no.856865

Item 10
Shawbury, Rapra Technology Ltd., 2002, pp.vii, 180, 25 cm, 95T
PRACTICAL GUIDE TO THE ASSESSMENT OF THE USEFUL LIFE OF PLASTICS
Brown R P; Greenwood
Rapra Technology Ltd.; ERA Technology Ltd.
This publication aims to provide practical guidance on assessing the useful service life of plastics. It covers test procedures and extrapolation techniques together with the inherent limitations and problems. It is particularly concerned with applications where a numerical prediction of lifetime is attempted. Durability is examined in its broadest sense, covering all aspects of irreversible property change with time and use, concentrating on the most common environmental effects and the most important mechanical properties. 38 refs.
EUROPEAN COMMUNITY; EUROPEAN UNION; UK; WESTERN EUROPE
Accession no.856079

Item 11
Geosynthetics International
8, No.6, 2001, p.577-97
MICROSCALE STUDY OF GEOMEMBRANE-GEOTEXTILE INTERACTIONS
Frost J D; Lee S W
Georgia, Institute of Technology; Korea, Institute of Construction Technology
Quantitative measures of surface roughness were used as the basis for investigating the effect of topography on the interface shear mechanism of HDPE geomembrane/non-woven geotextile interfaces. The results showed that the interface strength and mechanisms could be quantitatively related to the surface roughness of the geomembrane. The peak and residual interface strengths increased markedly through the use of textured geomembranes. For textured geomembranes, the peak interface strength was due to the micro-texture of the geomembrane, but the residual interface strength was primarily attributed to macro-scale surface roughness that pulled and broke the filaments of the geotextile. The effect of geomembrane wear on the stress-strain response was quantified. The results obtained provided a quantitative framework that could lead to a significantly improved basis for the selection of geotextiles and geomembranes in direct contact. 15 refs.
KOREA; USA
Accession no.854696

GEOPOLYMERIC PRODUCTS FROM WASTE MATERIALS
Siloxo is active in the licensing of a geopolymer process that fuses aluminium and silicon based waste materials into solid concrete-like products. Siloxo uses as materials fly ash, blast furnace slag, waste concrete, plastic, glass and paper, transforming them into geopolymers, which are a type of artificial rock that is stronger and more durable than concrete. Siloxo claims these materials can be produced cheaper than conventional concrete/cement, using either virgin or waste materials. The inorganic polymer mix can be poured at ambient temperatures like ordinary concrete, but it sets to full strength much more rapidly than concrete and attains higher strength than concrete.
SILOXO PTY.LTD.
AUSTRALIA
Accession no.853140

EXPERIMENTAL INVESTIGATION OF THE INTERACTION MECHANISM AT THE EPS GEOFOAM-SAND INTERFACE BY DIRECT SHEAR TESTING
Xenaki V C; Athanasopoulos G A
Patras, University
The interaction mechanism at the expanded PS(EPS) geofoam-sand interface was investigated by direct shear testing. The aim was to study the interface behaviour and examine its dependence on the EPS geofoam density, void ratio of sand, mean particle size of sand and particle shape. The interface behaviour was described by interface shear versus normal stress envelopes from which apparent (tangent) values of interface friction angle and adhesion could be estimated. The experimental results are presented and then analysed in order to draw conclusions regarding the type of interface behaviour and its dependence on these parameters. The experimental results were also interpreted by using a proposed conceptual framework that was believed satisfactorily to describe the role of the basic parameters involved in the problem. 27 refs.
EUROPEAN COMMUNITY; EUROPEAN UNION; GREECE; WESTERN EUROPE
Accession no.850388

TYRES ARE A GREAT DEAL FOR SUPER TARGET STORE
A Super Target Store, under construction in 2001, was anticipating up to 6,000 shoppers each day during the approaching holiday season and 10 to 15 freight trucks of merchandise arriving every day of the year. But they couldn’t reach the doors. Access over soft soils was the problem facing engineers on the Minnetonka, MN construction site of the large upscale retailer. The solution
References and Abstracts

38 © Copyright 2003 Rapra Technology Limited

turned out to be Recycled-Tire Engineered Aggregate (R-TEA). With only a few months to go before the October 14, 2001 opening of the store, soil engineers had a real design challenge. The soil was so soft behind the store that it couldn’t support construction of a driveway, receiving area or underground utilities. Braun InterTec knew that they had to remove the heavy organic soils and use some kind of lightweight fill. Bel Air Excavating selected R-TEA, manufactured by First State Tire Recycling. Details are given.

FIRST STATE TIRE RECYCLING
USA

Accession no.850169

Item 16
British Plastics and Rubber
MASTERBATCHES TURN BASE POLYMERS INTO GEOMEMBRANES

Cabot has introduced a range of masterbatches for the production of geomembranes and geotextiles used in civil engineering. Geosynthetic masterbatches are added to base polymers by geomembrane manufacturers to meet performance requirements for different situations such as landfill sites, lagoons, retaining walls, embankments and highways. They are compatible with most grades of PE, PP and PVC. Products incorporate different grades of carbon black to provide effective protection against deterioration as a result of heat or exposure to UV light. Most masterbatches contain antioxidant packages for long term protection against heat ageing as well as safety during processing.

CABOT CORP.
USA
Accession no.845332

Item 17
Plastiques & Elastomeres Magazine
53, No. 5, June/July 2001, p. 34-7
French
TEXTILE SOLUTIONS UNDERGROUND
Gouin F

The use of plastics geotextiles in soil reinforcement, stabilisation and drainage and other civil engineering applications is discussed, and materials developments by a number of companies are reviewed.

TERRAM FRANCE; GRILTEX; TERAGEOS; DU PONT DE NEMOURS E.I., & CO INC.; HUESKER FRANCE; BIDIM GEOSYNTHETICS SA
EUROPEAN COMMUNITY; EUROPEAN UNION; FRANCE; USA; WESTERN EUROPE
Accession no.842612

Item 18
Scrap Tire News
16, No. 1, Jan. 2002, p. 3
STANDARD FOR TYRE CHIPS USED AS AGGREGATE IN SEPTIC TANK ABSORPTION SYSTEMS

Chips produced from recycled tyres may be used as course aggregate in septic tank absorption systems and may be substituted for mineral aggregate on a one-for-one volumetric basis. The specifications that the chips must conform to for this application are outlined.

USA
Accession no.842252

Item 19
Geosynthetics International
8, No. 4, 2001, p. 327-42
SHEAR BEHAVIOUR OF GEOSYNTHETICS IN THE INCLINED PLANE TEST - INFLUENCE OF SOIL PARTICLE SIZE AND GEOSYNTHETIC STRUCTURE

Lopes P C; Lopes M L; Lopes M P
Porto, Universidade; Santiago, University

The results are reported of a study of the shear behaviour of several geosynthetics carried out using inclined plane shear tests to characterise the interaction mechanism at the soil-geosynthetic interface. Geosynthetics examined were a HDPE uniaxial geogrid, PP biaxial grid, PP non-woven, spunbonded geotextile, PP woven geotextile, HDPE smooth geomembrane and HDPE rough geomembrane. The effects of soil particle size, geosynthetic structure and test method on the behaviour of the geosynthetics are discussed. 9 refs.

EUROPEAN COMMUNITY; EUROPEAN UNION; PORTUGAL; WESTERN EUROPE
Accession no.841825

Item 20
Geosynthetics International
8, No. 4, 2001, p. 283-301
CONSOLIDATION EFFICIENCY OF NATURAL AND PLASTIC GEOSYNTHETIC BAND DRAINS

Jang Y S; Kim Y W; Park J Y
Dongguk, University; DaeWoo Engineering Inc.

The consolidation efficiency of coir/jute and plastic geosynthetic band drains was investigated using laboratory tests and a three-dimensional numerical flow model. The model was validated by comparing the predictions with laboratory consolidation data and the efficiency of the drains evaluated by changing the installation depth. 7 refs.

KOREA
Accession no.841823

Item 21
Geosynthetics International
8, No. 3, 2001, p. 233-70
INFLUENCE OF CREEP AND STRESS-RELAXATION OF GEOSYNTHETIC REINFORCEMENT ON EMBANKMENT BEHAVIOUR
Li A L; Rowe R K
Kingston, Queen’s University

The results are reported of an in depth investigation into the effects of viscous behaviour of geosynthetic reinforcement made from HDPE, PP or PETP on the short-term and long-term performance of basally reinforced embankments constructed over soft inviscous foundations. The magnitude of creep and stress relaxation of the reinforcement under limit-state and working stress conditions and the effects on stability and deformations of the system were examined by numerically simulating the construction of the embankments reinforced with the viscous reinforcement and with inviscous reinforcement. 62 refs.

CANADA
Accession no.833125

Item 22
Geosynthetics International
8, No.3, 2001, p.221-32
CANOPY FLOW EQUATION FOR EROSION CONTROL GEOSYNTHETICS
Hytiris N; McKay D J; Addison P S
Glasgow, Caledonian University; Napier, University

The flow field for four commercially available erosion control geomats made from PE, PP and polyamide 6, was investigated during initial geomat placement where vegetation did not have time to grow within the mat structure. Tests were carried out in an experimental flume lined with each geomat in turn and a one-dimensional laser Doppler anemometer utilised to determine the velocities within the flow field at the fluid-geomat interface. Using the data obtained, a modified log-law equation having the same form as canopy flow equations used in meteorology was developed for predicting the downstream flow velocities above the geomat. 21 refs.
EUROPEAN COMMUNITY; EUROPEAN UNION; UK; WESTERN EUROPE
Accession no.833124

Item 23
Advanced Materials & Composites News
BLAST MITIGATION WITH COMPOSITES, IN THE WORKS, “BIG TIME”

The manager of the Pentagon’s ongoing renovation programme has said that the hijacked aircraft, which crashed into the Pentagon on September 11, hit a portion of the building that had been renovated and reinforced with blast resistant windows, a special reinforced steel construction and fragment- and fibre-resistant “Kevlar” fibre fabric placed between vertical wall studs just below the windows. It is understood that the material used below the windows in the first part of the renovation is not Kevlar from DuPont, but rather a “geogrid mesh material” (probably polyester fibre).
US, ARMY CORPS OF ENGINEERS
USA
Accession no.829815

Item 24
Geosynthetics International
8, No.2, 2001, p.135-62
SHEAR STRENGTH CHARACTERISTICS OF PVC GEOMEMBRANE-GEOSYNTHETIC INTERFACES
Hillman R P; Stark T D
Golder Associates Inc.; Illinois, University

The shear strength of PVC geomembrane-geosynthetic interfaces was investigated by means of torsional ring shear and large-scale direct shear testing. The smooth and faille-finished sides of the geomembrane were subjected to shear testing against several non-woven geotextiles, a geonet, a drainage composite and geosynthetic clay liner. The interfacial shear behaviour of the PVC geomembrane is compared with that of a HDPE geomembrane and two flexible PE geomembranes and the effects of the type of non-woven geotextile fibre, mass per unit area and calendering on the interfacial shear strength of the PVC geomembrane assessed. 19 refs.
USA
Accession no.828150

Item 25
Geosynthetics International
8, No.2, 2001, p.97-112
INVESTIGATION AND MODELLING OF TWO COMPOSITE LANDFILL COVERS
Finley C A; Holtz R D
Texas, University; Washington, University

The results are reported of a field investigation of final covers at two municipal solid waste landfills in the USA and an evaluation of differential settlements occurring at both these locations after several years of service. The final covers included a HDPE geomembrane barrier, a non-woven geotextile filter and soil layers for drainage and vegetative growth. The differential settlements of the covers were modelled using a finite difference computer program and the results obtained were employed to relate geomembrane strain to surface settlement characteristics. A general design method for composite landfill covers spanning voids was also developed using the finite difference model. 12 refs.
USA
Accession no.828149
Item 26
Geosynthetics International
8, No.1, 2001, p.81-96
LONG-TERM VARIATIONS OF FORCE AND STRAIN IN A STEEP GEOGRID-REINFORCED SOIL SLOPE
Fannin R J
British Columbia, University
Measurements were made of the soil temperature and the force and strain in a steep soil slope uniaxially reinforced with a HDPE geogrid over a 10 year period. It was found that a non-linear increase of force occurred with time, which was attributed to deformation of the structure as a result of creep of the backfill sand. Strain in the reinforcement exhibited a complex variation with time, which was considered to be due mainly to the non-linear increase of force and creep of the geogrid reinforcement.
27 refs.
CANADA
Accession no.828148

Item 27
Geosynthetics International
8, No.1, 2001, p.49-80
COMPARISON OF THE DURABILITY OF GEOTEXTILES IN AN ALKALINE MINE TAILINGS ENVIRONMENT
Grubb D G; Diesing W E; Cheng S C J; Sabanas R M
Apex International Inc.; Drexel, University; NTH Consultants Ltd.
The results are reported of outdoor exposure tests carried out on a woven multi-filament PETP geotextile and on two non-woven needle-punched PP geotextiles with carbon black in Peru and the USA. Also reported are the results of tests carried out on five geotextiles, including the above geotextiles and two non-woven needle-punched PETP geotextiles) embedded in freshly deposited alkaline tailings having a pH of 11.3 and 178 mg/L total cyanide. The geotextiles were subjected to grab tensile, trapezoidal tear and index puncture testing and the retained strengths of the geotextiles compared. 16 refs.
USA
Accession no.828147

Item 28
Plastic culture
2, No.120, 2001, p.146-7
English; Spanish; French
CROP PROTECTION AND FORCING
The use of geotextiles, which allow a protective wall permeable to air and light to be formed around crops, is briefly discussed.
EUROPEAN COMMUNITY; EUROPEAN UNION; SPAIN; WESTERN EUROPE
Accession no.826475

Item 29
Proceedings of the National Science Council Republic of China
25, No.4, July 2001, p.211-7
TENSION OF GEOSYNTHETIC MATERIAL REGARDING SOILS ON LANDFILL LINER SLOPES
Liu C-N
Taiwan, National Chi-Nan University
A simple procedure for analysing tensile loading in geosynthetic materials caused by soils on landfill liner slopes is proposed. Predictions obtained using this procedure, which takes into account force equilibrium and displacement compatibility, are compared with conventional analytical methods and with the results of experiments conducted on a liner system with a 2-mm thick HDPE geomembrane, which validate the new approach. 12 refs.
TAIWAN
Accession no.826342

Item 30
Scrap Tire News
15, No.7, July 2001, p.1/3
I-880 INTERCHANGE SHOWCASES TIRE RECYCLING POTENTIAL
A brief report is presented on the use of shredded scrap tyres as lightweight fill in the reconstruction of an interchange ramp for one of the California Bay Area’s busiest freeways. The tyres are shredded down to 2 to 12 inch chips and wrapped in a liner of geotextile fabric and soil. The use of tyre chips is said to cause less settlement than soil, allowing paving and construction to start much sooner.
CALIFORNIA, DEPT. OF TRANSPORTATION; CALIFORNIA INTEGRATED WASTE MANAGEMENT BOARD
USA
Accession no.825057

Item 31
Revista de P lasticos Modernos
80, No.531, Sept.2000, p.280-5
Spanish
PVC SHEETS IN AGRICULTURE AND THE CONSTRUCTION OF IRRIGATION RESERVOIRS
Alcina A
PYN SA de CV
The use of PVC geomembranes in combination with other geosynthetic materials in the construction of reservoirs for agricultural irrigation is discussed. 3 refs.
MEXICO
Accession no.818394
Item 32
Revista de Plasticos Modernos
80, No.531, Sept.2000, p.252/6
Spanish
STANDARDISATION OF PLASTICS IN AGRICULTURE
Ruiz J M
ANAIP
Standardisation in Spain and the European Union relating to plastics and rubber products for use in agriculture and horticulture is examined. Spanish standards covering pipes, geomembranes and greenhouse covering films are reviewed.
IRANOR; AENOR; CEN; COFACO; INTERNATIONAL STANDARDS ORGANISATION EU; EUROPEAN COMMUNITY; EUROPEAN UNION; SPAIN; WESTERN EUROPE; WESTERN EUROPE-GENERAL; WORLD
Accession no.818390

Item 33
Plastics News International
July 2001, p.20
FIBRE-GRADE MASTERBATCHES LAUNCHED
Hubron has introduced two new black fibre-grade masterbatches. Loaded at 30% and 40% respectively, the PP-based grades PPFB 6175 and PPFB 6180 possess excellent dispersion qualities, high opacity and optimum UV properties. Said to be ideal for fibre extrusion for carpets and geotextiles, they facilitate rapid extrusion and minimise downtime from fibre breakages and filter blockages. Other features include an antioxidant package and flexibility of use for other extrusion processes. This abstract includes all the information contained in the original article.
HUBRON LTD.
EUROPEAN COMMUNITY; EUROPEAN UNION; UK; WESTERN EUROPE
Accession no.816923

Item 34
Patent Number: US 6139955 A1 20001031
COATED FIBER STRANDS REINFORCED COMPOSITES AND GEOSYNTHETIC MATERIALS
Girgis M M
PPG Industries Ohio Inc.
Disclosed is a fibre strand useful in composites and geosynthetics. The fibres have applied to at least a portion of their surfaces a base layer of a base coating composition and a principal layer of an aqueous coating composition different from the base coating composition. The aqueous coating composition includes a blend of (1) a halogenated vinyl polymer and (2) an elastomeric polymer, the blend being essentially free of a monoolefinic material.
USA
Accession no.806673

Item 35
West Conshohocken, Pa., 1999, pp.3. NALOAN
ASTM D 4545-; PRACTICE FOR DETERMINING THE INTEGRITY OF FACTORY SEAMS USED IN JOINING MANUFACTURED FLEXIBLE SHEET GEOMEMBRANES
American Society for Testing & Materials
ASTM D 4545-
Version 86 (R1999). Photocopies and loans of this document are not available from Rapra.
USA
Accession no.801067

Item 36
Plastics News(USA)
12, No.41, 11th Dec.2000, p.15
GSE LINING TEAMS UP WITH STEVENS
GSE Lining Technology, headquartered in Holyoke, Mass., and Houston-based Stevens Geomembranes have signed a joint manufacturing agreement for the production of reinforced and unreinforced PP geomembranes. Stevens Geomembranes is a worldwide producer of reinforced PP geomembranes and GSE makes unreinforced geosynthetic liners. Under the agreement, the two companies will cross-utilise manufacturing capabilities to supply PP products the other does not currently manufacture. This abstract includes all the information contained in the original article.
GSE LINING TECHNOLOGY INC.; STEVENS GEOMEMBRANES
USA
Accession no.799111

Item 37
Boston, Ma., 8th-11th Oct.2000, p.522G-H
POLYURETHANE COMPOSITE LINING SYSTEM - LINING OF DIRT AND CONCRETE DITCHES
Payne L; Guether R; Markusch P H
Innovative Process Corp.; Bayer Corp. (American Plastics Council, Alliance for the Polyurethanes Industry)
As the demands placed on the nation’s finite water supply continue to grow, conservation efforts become critical in high-consumption uses such as irrigation. Efforts to control this water loss have included lining the ditches with concrete, geomembranes or clay. But these lining solutions can take too long to install, be very expensive, and experience tears, cracks and other failures that limit effectiveness. The PU composite liner described overcomes many of these disadvantages and is a valid solution for the lining of deteriorated concrete or dirt ditches. The key difference between this new composite
References and Abstracts

liners and other geomembranes is that the geotextiles soaked with the PU resin are applied wet. This means that the composite liner can anchor itself to the concrete and adheres to itself in the overlapping portions, resulting in a seamless, permanent flexible liner that will retain water, and neither crack nor tear. This cost-effective and easy-to-install PU composite liner has been successfully used for lining of numerous dirt and concrete ditches. Brief details are given.

USA
Accession no.794328

Item 38

Plastics, Rubber and Composites
29, No.1, 2000, p.51-8

FINITE ELEMENT SIMULATION OF GEOGRID MANUFACTURE USING LARGE DEFORMATION ELASTIC FORMULATION
Caton Rose P; Sweeney J; Collins T L D; Coates P D
Bradford, University

An elastic model of large solid polymer deformations is used as a basis for numerical predictions of the shapes of PE geogrids. These netlike products are made by solid phase deformation at elevated temperatures of extruded sheet containing arrays of suitably shaped holes. The elastic constitutive model is based on a theory of interacting polymer chains and is implemented within the finite element package ABAQUS in both two and three dimensions. Deformations correspond to extension ratios of up to eight. Good predictions of the final shapes of the geogrid products are obtained. It is concluded that the methods used are a valuable product development tool.

10 refs.

EUROPEAN COMMUNITY; EUROPEAN UNION; UK; WESTERN EUROPE
Accession no.786449

Item 39

Helsinki, Finland, 13th-15th June 2000, paper 16

RECYCLING USED TYRES IN PE NATURAL GAS PIPE CONSTRUCTION SITES
Tulokas T
Haminan Energia Oy
(Nordic Council of Rubber Technology)

A method is introduced in which a PE natural gas pipe is placed on used tyres in an excavated channel. The method differs from traditional forms of gas pipe placement in that the initial filling of the channel takes place after the pipe has been placed in the channel. In the traditional method of gas pipe placement, the channel is first excavated, the geotextile is then installed, a sandbed prepared, the gas pipe placed on the sandbed and the channel finally filled with the remaining soil layers. The advantage of the method presented is that the gas pipe can be placed in the channel immediately after installation of the geotextile. The method using tyres is a variation of one presented earlier in which sand-filled sacks were used.

EUROPEAN UNION; FINLAND; SCANDINAVIA; WESTERN EUROPE
Accession no.787055

Item 40

Industrial & Engineering Chemistry Research
39, No.8, Aug. 2000, p.2925-34

MECHANISM OF POLYSIALATION IN THE INCORPORATION OF ZIRCONIA INTO FLY ASH-BASED GEOPOLYMERS
Phair J W; Van Deventer J S J; Smith J D
Melbourne, University

Zirconia was used as an inert reference to examine the effects of a non-aluminosilicate source on the chemical and physical properties of a geopolymer matrix. FTIR, X-ray diffraction and compressive strength analyses were used to characterise the matrix. 33 refs.

AUSTRALIA
Accession no.786449

Item 41

Surrey, ERA Technology Ltd., 1998, 7 papers. 60.00. 30cms. 14/9/00

INSTALLATION DAMAGE IN GEOSYNTHETICS. PROCEEDINGS OF A CONFERENCE HELD SURREY, UK, 10TH NOV. 1998

This conference examines site evidence of how damage occurs in geosynthetics and how it is assessed. Simulated site testing and laboratory index testing are correlated with on-site experience. Papers highlight the procedures being adopted by various countries and debate the way forward towards a universal method of testing and specification. Three main sessions - installation damage - the phenomenon, test methods, and improvements in the resistance of geosynthetics of non-woven materials are included, with a final discussion session focusing on specification of resistance to damage.

Accession no.784998

Item 42

Plastics News International
Aug.2000, p.6

FLUOROPOLYMER TANK LINERS DO MORE THAN JUST CONTAIN CHEMICALS

By acting as the primary method of containment, loose-fit impervious fluoropolymer tank liners meet stringent environmental storage regulations and extend tank life. With its unique combination of characteristics, Dyneon HTE, comprised of hexafluoropropylene, tetrafluoroethylene and ethylene monomers, operates in severe chemical and temperature environments. In addition, it is weldable to itself, allowing ease of
installation and design flexibility. It has been the material of choice for Interline Plastics, an international leader in the manufacture of impervious, loose-fit internal liners using chemical-resistant materials.

DYNEON CORP.; INTERLINE PLASTICS
NORTH AMERICA
Accession no.782526

Item 43
Surrey, ERA Technology Ltd., pp. 92. 60.00.
CREEP AND ASSESSMENT OF GEOSYNTHETICS FOR SOIL REINFORCEMENT. SEMINAR PROCEEDINGS (ERA Technology Ltd., International Geosynthetics Society)

This seminar deals with the measurement of creep and how the results are applied in the assessment of soil reinforcements. Aspects studied include design lifetime of geosynthetics, and their safety margins. As design load calculations vary from country to country presentations from Europe and the US are included. Papers include practicalities of measurement of creep and stress-rupture, the stepped isothermal method (SIM) for time-temperature superposition, derivation of design parameters and partial safety factors from laboratory data, the manufacturer’s views on durability and certification, approval procedures for geosynthetics for soil reinforcement applications - UK practice, and creep and assessment practices for geosynthetics reinforcements in the USA.

Accession no.781471

Item 44
New Orleans, La., 22nd-26th Aug.1999, p.378-9
ENVIRONMENTAL STRESS CRACK IN POLYETHYLENE
Prasad A
Equisstar Chemicals LP
(ACS, Div.of Polymeric Materials Science & Engng.)

When PE is exposed to an aggressive environment under low stresses, small cracks may initiate and propagate through the material and can lead to catastrophic failure. The environmental stress-cracking (ESC) failure mechanism involves a macroscopic brittle-type fracture in materials. ESCR is the time that a material under specific conditions takes to fail in the ESC-type mode. A lab ESCR test called the 3-PB test, which is based on the theory of linear-elastic fracture mechanics, has earlier been proposed. The theory requires that the stress intensity factor (KI) be constant and have a certain minimum value for crack propagation to occur. Work with the 3-PB test has shown that this test yields ESCR values of better precision than the bottle tests. Another test, the NCTL test, is used to evaluate ESCR of polyolefin geomembrane sheets. This is essentially a simple uni-axial tensile test, in a temperature-controlled bath of some aggressive environmental agent. The specimens are small tensile bars, with a notch in one face of the specimen. A load is applied along the tensile axis of the sample by means of a lever arm, inducing a tensile stress, which, in combination with the aggressive agent, results in the ESC fracture of the sample at the notch. Resin manufacturers and processors have given little attention to the NCTL test method in terms of their ESCR-measuring capabilities for the blow-moulding resins. The primary objective is to evaluate the effects of thickness and morphology on ESCR properties of various blow moulding resins and blown bottles using the 3-PB and NCTL tests. 16 refs.

USA

Accession no.780555

Item 45
Plasticulture
1, No.119, 2000, p.145-60
English; French; Spanish
RESERVOIRS FOR AGRICULTURAL IRRIGATION WITH PLASTIC SHEETS OF (PVC-P)
Carlos K; Palacin G
Alkor Draka Iberica SA

Water storage for agricultural needs is not new. For hundreds of years there have been attempts to break the dependence on seasonal cycles, storing natural resources in times of abundance and keeping them for times of shortage. Water shortages for agricultural use is growing because of the increasing population, cities and industrial demand, a greater amount of agricultural land open to irrigation, climatic changes caused by deforestation, and/or global warming. The use of PVC sheeting for agricultural reservoirs is described.

EUROPEAN COMMUNITY; EUROPEAN UNION; SPAIN; WESTERN EUROPE

Accession no.778111

Item 46
Plasticulture
1, No.119, 2000, p.124-42
English; Spanish; French
USE OF PLASTIC MATERIALS FOR THE MANAGEMENT OF IRRIGATION WATER
Losada A
Madrid, Universidad Politecnica

The water cycle shows that this natural resource is renewable, but its availability is limited. Social and economic growth generates a higher water demand. Alternative uses for these resources keep us constantly under pressure. Irrigation water is particularly scarce because of the great amount of water that an irrigated crop demands, sometimes as much as 15,000 cub.m/ha/year. Rational management of irrigation water, therefore,
has a great importance and the control and reduction of water use deserves special attention. The use of plastic materials has contributed to a real technological revolution in irrigation and it has sometimes helped scientific advances that have an enormous potential to improve the use of water. On the one hand, irrigation networks have been improved by plastic irrigation equipment; on the other, water has been brought under control by mulching techniques and plastic greenhouses. Plastics also play an important role in the manufacture of ancillary equipment, accessories and communication systems, which are essential elements to regulate and automate crop tasks and, particularly, irrigation. The development experienced by water management techniques in irrigation networks is described. It is suggested what current irrigation technology would be like without the support of plastic materials for the last fifty years. The importance of plastics for a better use of water in crops is underlined.

EUROPEAN COMMUNITY; EUROPEAN UNION; SPAIN; WESTERN EUROPE

Accession no.778110

Item 47

EVALUATION OF THE DURABILITY OF POLYPROPYLENE GEOTEXTILE USING HIGH PRESSURE OXIDATIVE INDUCTION TIME TEST
Hsuan Y G; Konrath L
Drexel,University
(SPE,Philadelphia Section; SPE,Polymers Analysis Div.; ASTM)
The high-pressure oxidative induction time (HP-OIT) test was adopted by the ASTM D 35 geosynthetic committee in 1996, as ASTM D 5885. The test is designed to evaluate the stabilisation of polyolefin geosynthetics, such as PE and PP products. A series of HP-IT tests is utilised to assess the effects of isothermal temperature and pressure on the oxidation rate. A single type of non-stabilised PP fibre is used. The isothermal temperature varies from 120 to 150 deg.C at pressures ranging from 2.8 to 4.8 MPa. The relationship between oxidation rate and isothermal temperature can be modelled by the Arrhenius equation at all pressures. However, the increase in pressure does not enhance the rate of reaction at these elevated temperatures. 5 refs.

USA
Accession no.775946

Item 48

UTILISING PVC GEOMEMBRANES FOR LANDFILL AND POND LINERS
Rohe F P

Environmental Protection Inc.
(SPE,Vinyl Div.)
Flexible PVC liners have been successfully used for containment applications since the 1960s. The fabrication and installation of a typical PVC geomembrane for containment applications are described. The benefits of using PVC versus some of the alternative geomembranes are also discussed. 10 refs.

USA
Accession no.769494

Item 49
90, No.4, 1999, p.580-5

INSTRUMENTAL MEASUREMENT OF STRAIN IN NONWOVEN GEOTEXTILE FABRICS
Russell S J; Dobb M G
Leeds,University

Geotextile fabrics and geomembranes are subjected to considerable compressive forces in situ, which may affect their functional performance or lead to premature failure. The measurement of strain developed in such fabrics is therefore of considerable practical importance. A novel approach using a quantitative image analysis technique is described, which permits rapid and accurate measurement of the localised strains developed in non-woven geotextile fabrics when subjected to compression by stones, gravel or other hard materials. The technique is intended to be used in conjunction with the cylinder performance test, previously developed to simulate the strains imposed on geotextile fabrics in the ground. 4 refs.

EUROPEAN COMMUNITY; EUROPEAN UNION; UK; WESTERN EUROPE
Accession no.761127

Item 50
Journal of Polymer Engineering
19, No.5, 1999, p.315-32

CHEMICAL COMPATIBILITY TESTING OF LINEAR LOW DENSITY POLYETHYLENE GEOMEMBRANE - SORPTION/DESORPTION, DIFFUSION AND SWELLING STUDIES IN THE PRESENCE OF ORGANIC LIQUIDS
Aminabhavi T M; Naik H G
Karnatak University

Chemical compatibility of LLDPE geomembrane was studied by measurement of sorption/desorption and diffusion for 14 organic liquids at 25, 50 and 70C. Sorption results were obtained by a gravimetric method and diffusion coefficients were calculated from Fick’s equation for the initial linear data points of the time-dependent sorption/desorption curves. Permeability coefficients were calculated from the desorption and sorption values. Swelling was studied by measuring the
increase in thickness and diameter and thereby calculating the volume dilation of the geomembrane. From the temp. dependence of sorption and diffusion coefficients, the Arrhenius activation parameters were calculated. Liquid concentration profiles were also calculated theoretically from a solution of the Fick’s equation under appropriate initial and boundary conditions. The results are discussed in relation to the possible application of the LLDPE for a specific hazardous site involving exposure to the chosen liquids. 27 refs.

INDIA
Accession no.760803

Item 51
High Performance Textiles
Jan.2000, p.7-8
STRONGER SACK FOR CONTROLLING EROSION OF SHORELINES
A method of producing bags used in controlling the erosion of shorelines is covered by US Patent 5 902 070 by Bradley Industrial Textiles. The invention claims to have an improved structure reinforcing the seams, and that this form of seaming enhances the overall strength of the entire structure. Production of the elongated tubular geotextile bag which can be made from woven synthetic fibres such as nylon or PP, is described, together with the method of joining the two sheets.
BRADLEY INDUSTRIAL TEXTILES INC.
USA
Accession no.759651

Item 52
Plastics News(USA)
11, No.35, 18th Oct.1999, p.4
PLASTIC POTHOLE REPAIR PAVING WAY TO SAVINGS
Ledson S
Using components made predominantly from recycled plastic waste, Parsec has introduced a pothole and roadway repair system for asphalt and concrete roads. A cross-laminated PE liner covers the bottom of the pothole, while a PP geogrid mesh interwoven with PVC rebar tubes is laid on top. The rebar tubes act as reinforcement rods that will allow the pothole filler to withstand vehicle impact, provide stability and prevent deterioration. The filler is then covered by traditional asphalt.
PARSEC INC.
USA
Accession no.751187

Item 53
Patent Number: US 5934990 A 19990810
MINE STOPPING
Steffenino J E; Shean T J; Holstein C D; Zelanko J C
Tensar Corp.; Sandvik Rock Tools Inc.

A mine tunnel ventilation control device and method for constructing same quickly with an easily transportable matrix material is disclosed which provides a rigid flame retardant barrier wall. The air flow stopping includes a peripheral frame extending about and across a tunnel opening to which is secured a matrix material, preferably in the form of a composite including a sheet of very strong grid material, such as a biaxially oriented integral geogrid or the like, bonded to a sheet of a textile material, such as a non-woven, needle-punched, geofabric or the like which spans the apertures of the geogrid. At least one side of the matrix material, and preferably both sides, are covered with a sealant composition to prevent passage of air through the mine stopping and to develop structural rigidity.

USA
Accession no.749770

Item 54
Polymer Degradation and Stability
65, No.1, July 1999, p.25-36
INFLUENCE OF CARBON BLACK ON PROPERTIES OF ORIENTATED POLYPROPYLENE. II. THERMAL AND PHOTODEGRADATION
Horrocks A R; Mwila J; Miraftab M; Liu M; Chohan S S
Bolton, Institute of Higher Education
The effect of carbon black on thermal and photooxidative degradation of oriented PP geotextile tapes was studied. PP tapes containing carbon black with different particle sizes, structures (or aggregate shape), specific surface volatile content and concentrations were exposed separately to circulatory air ovens at 130C and UVB lamps at 60C, respectively. The exposed tapes were studied using tensile tensiometric, IR spectrophotometric and thermal analytical (DSC) techniques. The results obtained are presented and discussed. The overall evidence suggested that carbon blacks having the smallest particle size, possibly high structure and low volatile contents, would yield PP tapes having optimum thermal and UV stabilisation behaviours. 28 refs.
EUROPEAN COMMUNITY; EUROPEAN UNION; UK; WESTERN EUROPE
Accession no.744058

Item 55
Revista de Plásticos Modernos
77, No.512, Feb.1999, p.201-7
Spanish
GEOMEMBRANES IN THE WATERPROOFING OF SMALL RESERVOIRS
Martinez F J
Valencia, Polytechnical University
The use of plastics and rubber geomembranes in water insulation for small reservoirs is discussed. Particular attention is paid to PVC and HDPE, and other materials
examined include LDPE, chlorinated and chlorosulphonated PE, EPDM and butyl rubber. Aspects of reservoir construction and geomembrane installation are considered, and Spanish standards relating to test methods for PVC, HDPE and EPDM membranes are reviewed.

**EUROPEAN COMMUNITY; EUROPEAN UNION; SPAIN; WESTERN EUROPE**

Accession no.742570

**Item 56**

*High Performance Textiles*

July 1999, p.7-8

**TEMPORARY ROAD SURFACES**

A woven structure that can be laid much like carpet across soft, sandy and swampy ground will help all types of vehicle to traverse such areas safety, according to US Patent 5,946,890. The fabric is portable and has a weight of about 725 gsm. When laid, the fabric will have a thickness of about 1 cm.

**SOCIETE A RESPONSABILITE LIMITEE DESCHAMPS**

EUROPEAN COMMUNITY; EUROPEAN UNION; FRANCE; WESTERN EUROPE

Accession no.739197

**Item 57**

*Journal of Applied Polymer Science*

72, No.10, 6th June 1999, p.1291-8

**SORPTION/DESORPTION STUDIES ON POLYPROPYLENE GEOMEMBRANE IN THE PRESENCE OF HAZARDOUS ORGANIC LIQUIDS**

Aminabhavi T M; Naik H G

Karnatak University

Experimental results of sorption/desorption obtained from a gravimetric method are presented for a PP geomembrane with various organic liquids at 25, 50 and 70 deg.C. The sorption data are fitted to an Arrhenius relationship to obtain the heat of sorption. The sorption/desorption data are analysed using an empirical equation. The swelling of the PP geomembrane is also studied for the chosen liquids. Experimental results and the derived quantities are discussed to study the chemical resistivity of the geomembrane. 18 refs.

**INDIA**

Accession no.734791

**Aminabhavi T M; Naik H G**

Karnatak University

Sorption/desorption results of halogen-containing liquids into HDPE, LLDPE, and PP geomembranes are presented at 25, 50 and 70 C. Sorption results were obtained by a gravimetric method, and diffusion coefficients were calculated by using Fick’s equation from the initial linear portions of the sorption/desorption curves. Swelling of the geomembranes was studied by measurement of the increase in volume, thickness, and diameter. From a temperature dependence of sorption and diffusion coefficients, the Arrhenius parameters were calculated. Liquid concentration profiles were computed using Fick’s equation for the appropriate initial and boundary conditions. The results were relevant to selection of geomembranes for specific applications in hazardous waste chemical ponds and other similar situations. 20 refs.

**INDIA**

Accession no.733504

**Item 59**

*Polymer International*

48, No.5, May 1999, p.373-81

**MOLECULAR MIGRATION OF LOW SORBING ORGANIC LIQUIDS INTO POLYMERIC GEOMEMBRANES**

Aminabhavi T M; Naik H G

Karnatak University

Laboratory test results of sorption/desorption for tetrahydrofuran, tetralin, 1,4-dioxan, methyl acetate, ethyl acetate and butyl acetate into HDPE, LLDPE, very low density PE and PP geomembranes at 25, 50 and 70 deg.C are presented. Partition coefficients are calculated from the measured increase in the mass of geomembranes immersed in the liquid of interest, from the initial value until the mass becomes constant. From the initial linear portions of the sorption curves, the diffusion coefficients of liquids into the geomembranes are calculated using the Fick equation. From a temperature dependence of sorption, diffusion and permeation coefficients, the Arrhenius parameters are calculated for each of these processes. Results of the preliminary findings reported might be useful in the applications of geomembranes in containment facilities. 41 refs.

**INDIA**

Accession no.732349

**Item 60**

*Journal of Plastic Film & Sheeting*

15, No.1, Jan.1999, p.47-56

**CHEMICAL COMPATIBILITY OF GEOMEMBRANES - SORPTION, DIFFUSION AND SWELLING PHENOMENA**

Aminabhavi T M; Naik H G

Karnatak University

Laboratory test results of sorption/desorption for tetrahydrofuran, tetralin, 1,4-dioxan, methyl acetate, ethyl acetate and butyl acetate into HDPE, LLDPE, very low density PE and PP geomembranes at 25, 50 and 70 deg.C are presented. Partition coefficients are calculated from the measured increase in the mass of geomembranes immersed in the liquid of interest, from the initial value until the mass becomes constant. From the initial linear portions of the sorption curves, the diffusion coefficients of liquids into the geomembranes are calculated using the Fick equation. From a temperature dependence of sorption, diffusion and permeation coefficients, the Arrhenius parameters are calculated for each of these processes. Results of the preliminary findings reported might be useful in the applications of geomembranes in containment facilities. 41 refs.

**INDIA**

Accession no.732349
The chemical compatibility results studied by measurement of sorption, diffusion and swelling of seven aromatic liquids into four geomembranes viz. HDPE, LLDPE, very low density PE and PP are presented at 25, 50 and 70 deg.C. Diffusion coefficients are calculated using Fick’s equation. The swelling of geomembranes is measured by monitoring the dimensional response of the membranes and thereby calculating the increase in volume. The results of this research could be useful in the proper selection of a suitable geomembrane for a specific application involving exposure to organic liquids. 7 refs.

INDIA
Accession no.732340

Item 61
Geosynthetics International
6, No.1, 1999, p.53-68
COMPARATIVE MODEL STUDY OF GEOSYNTHETIC PULL-OUT RESPONSE
Gurung N; Iwao Y
Saga, University

The analysis is described of reinforcement pull-out tests using a shear model that incorporates a hyperbolic shear stress-displacement relation for the soil-reinforcement interface. Numerical studies of pull-out tests were performed for small to large strains in inextensible and extensible reinforcements. Predictions based on a hyperbolic model of shear mobilisation were compared with a theoretical bilinear model presented by Madhav et al. Comparative parametric studies using both models were carried out for ranges of relative stiffness and bond resistance values. 18 refs.

JAPAN
Accession no.731468

Item 62
Geosynthetics International
5, No.6, 1998, p.637-45
BASIS FOR MODELLING CREEP AND STRESS RELAXATION BEHAVIOUR OF GEOGRIDS
Sawicki A
Poland, Institute of Hydro-Engineering

Based on the test data published in 1997 by Leschinsky et al., analytical models of the creep and stress relaxation of some geogrids are presented. It is shown that in the case of Geogrid C2 (HDPE) a standard rheological model described the experimental data in the low stress level range. In other cases, new rheological models can be developed, such as the new model proposed for Geogrid A1 (polyester). The models are defined by differential constitutive equations whose solutions are presented for creep at constant stress and stress relaxation at constant strain. Model parameters are also determined. 2 refs.

EASTERN EUROPE; POLAND
Accession no.715896

Technical product information is presented for Rallitape 410, a single strand extruded tape based on synthetic rubber for building applications and vehicle and tank construction. The tape is claimed to offer a high degree of recovery after compression, and can be used in applications such as lap jointing of roof sheets and gutters, glazing, and bonding geomembranes.

EUROPEAN COMMUNITY; EUROPEAN UNION; UK; WESTERN EUROPE
Accession no.729212

Item 64
Revue Generale des Caoutchoucs et Plastiques
No.768, May 1998, p.30-3
French
STADE DE FRANCE: PLASTICS IN THE FINAL
Delannoy G
An examination is made of applications of plastics in the Stade de France, a football stadium constructed for the 1998 World Cup in France. An underground PVC geomembrane produced by Alkor Draka was installed as a barrier to gases permeating from the site, which was previously occupied by a factory operated by Gaz de France. PVC sheeting produced by Braas was used in construction of the roofing, and the stadium seating was injection moulded by Grosfillex in a UV stabilised propylene copolymer.

ALKOR DRAKA; FILLON; SMAC ACIEROID SA; GROSFILLEX; BRAAS GMBH
EUROPEAN COMMUNITY; EUROPEAN UNION; FRANCE; GERMANY; WESTERN EUROPE
Accession no.721774

Item 65
Geosynthetics International
6, No.1, 1999, p.19-40
COMPARISON OF THE RESPONSE OF GEOSYNTHETICS IN THE MULTI-AXIAL AND UNIAXIAL TEST DEVICES
Bray J D; Merry S M
California, University; Utah, University

To evaluate the influence of the stress state induced during testing on the stress-strain response of geomembranes, strain-controlled multi-axial and wide strip tests were performed on specimens of elastic latex, PVC and HDPE. 29 refs.

USA
Accession no.731467
Item 66

Polymer
40, No.9, April 1999, p.2281-8
EFFECT OF APPLIED STRESS ON THE ALKALINE HYDROLYSIS OF GEOTEXTILE PETP. I. ROOM TEMPERATURE
East G C; Rahman M
Leeds,University
Details are given of the effect of tensile stress on the rate of hydrolysis of geotextile grade PETP in aqueous sodium hydroxide solution at room temperature. Surface properties were examined using SEM. An empirical equation was obtained which showed that the breaking load of the filaments decreased proportionally with time and with the square of the imposed stress. 25 refs.
EUROPEAN COMMUNITY; EUROPEAN UNION; UK; WESTERN EUROPE
Accession no.713694

Item 67

Plastics and Rubber Asia
GEOMEMBRANE SEALS MONTELL AWARD
A PP geomembrane used on a major Australian construction project is one of the Worldwide Award Winners in the Montell Polyolefins Worldwide Innovation Awards Program. The awards recognise innovations based on Montell’s new grades of PP resins. The geomembrane was used on the Domain tunnel, part of a 22 km motorway around Melbourne. The 1.6 km tunnel passes below the level of the water table, and near a river, making it essential to use a geomembrane to ensure it is watertight. The geomembrane was made by Nylex Polymer Products of Mentone. It was 2mm thick and made of Montell’s Astryn PP CA-721. Astryn can incorporate a high level of ethylene-propylene rubber, giving it good flexibility and tear resistance without using plasticisers. Details are given.
MONTELL POLYOLEFINS; NYLEX POLYMER PRODUCTS AUSTRALIA
Accession no.714097

Item 68

Geosynthetics International
EFFECT OF PH, RESIN PROPERTIES, AND MANUFACTURING PROCESS ON LABORATORY DEGRADATION OF POLYESTER GEOSYNTHETICS
Elias V; Salman A; Goulais D
Elias V.,& Associates; Brooklyn,Polytechnic University
An accelerated testing protocol was developed and a test programme implemented to assess the durability of PETP geosynthetics. The test results indicated that low-tenacity PETP commercial geosynthetic products were more susceptible to hydrolytic degradation than high-tenacity geosynthetics due to lower molec.wt. and a high number of carboxyl end groups. Tests conducted in acidic, neutral and alkaline solutions exhibited the same trends. 14 refs.
USA
Accession no.713694

Item 69

Revista de Plasticos Modernos
75, No.500, Feb.1998, p.187-95
Spanish
SYNTHETIC GEOMEMBRANES IN THE WATERPROOFING OF RESERVOIRS
Blanco M; Cuevas A; Aguiar E; Zaragoza G
Tenerife,Consejo Insular de Aguas; Spain,Ministry of the Environment
Applications of geomembranes in water insulation for reservoirs are examined, with particular reference to experience in Spain and the Canary Islands. A review is made of types of plastics and rubbers used, property requirements and developments in European Union and Spanish standards relating to waterproofing membranes. 28 refs.
BALTEN; CEDEX; ANFALAS; COMITE ESPANOL DE PLASTICOS EN AGRICULTURA EU; EUROPEAN COMMUNITY; EUROPEAN UNION; SPAIN; WESTERN EUROPE; WESTERN EUROPE-GENERAL
Accession no.710656

Item 70

Revista de Plasticos Modernos
Spanish
MAINTENANCE AND REPAIR OF RESERVOIRS
Romero D C
Comite Espanol de Plasticos en Agricultura
The performance characteristics, installation, repair and maintenance of plastics and rubber linings for reservoirs are discussed.
EUROPEAN COMMUNITY; EUROPEAN UNION; SPAIN; WESTERN EUROPE
Accession no.710603

Item 71

Polimery Tworzywa Wieloczasteczkowe
41, No.5, May 1996, p.307-10
Polish
ECOLOGICAL POLYETHYLENE PRODUCTS. PART I. POLYETHYLENE GEOMEMBRANES
Plock,R&D Centre of the Refinery Industry
Geomembrane applications are reviewed, with particular reference to those used as insulating materials for protecting underground and surface water and soil from contamination by refuse and leaching from waste disposal sites. The requirements to be met by such geomembranes
are summarised. The essential technical specifications and chemical resistance of the geomembranes made from low-density polyethylene at the Refinery R&D Centre at Plock are presented. Advantages and drawbacks of the geomembranes made from low-density and high-density polyethylene are compared. 3 refs. Articles from this journal can be requested for translation by subscribers to the Rapra produced International Polymer Science and Technology.

EASTERN EUROPE; POLAND
Accession no.706688

Item 72
Geosynthetics International
5, No.4, 1998, p.425-34
CREEP AND STRESS RELAXATION OF GEOTEXTILE-REINFORCED SOILS
Helwany S M B; Shih S
Wisconsin, University; Texas, University
Creep and stress relaxation occur simultaneously in a geosynthetic-reinforced soil structure. A new test apparatus is described which measures creep and stress relaxation simultaneously in a soil-geosynthetic composites. 11 refs.

USA
Accession no.706423

Item 73
Geosynthetics International
5, No.4, 1998, p.399-424
THEORETICAL MODEL FOR THE PULL-OUT RESPONSE OF GEOSYNTHETIC REINFORCEMENT
Madhav M R; Gurung N; Iwao Y
Saga, University
A new pull-out test model that calculates the soil-geosynthetic reinforcement interface shear stress for highly extensible geosynthetic reinforcement is proposed. Based on a new bilinear interface shear model, the geosynthetic pull-out test results are calculated with regard to the variation of the mobilised geosynthetic tension with distance, geosynthetic pre-yield and post-yield behaviour, and the effective and extended length of the geosynthetic reinforcement. The resulting non-linear equation for the soil-geosynthetic interface shear stress pull-out mechanism is nondimensionalised, expressed in a finite difference form, and solved numerically using the Gauss-Siedel technique. A parametric study is carried out for a range of relative stiffness values and interface shear stresses. Normalised load-displacement relationship and the variation of the pull-out force and reinforcement displacements, with distance along the reinforcement, are presented. 33 refs.

JAPAN
Accession no.704895

Item 74
Geosynthetics International
5, No.4, 1998, p.361-82
PULL-OUT RESISTANCE OF POLYESTER STRAPS AT LOW OVERBURDEN STRESS
Lo S C R
New South Wales, University
High tenacity polyester straps have been successfully used as the reinforcing elements for geosynthetic-reinforced soil walls. The pull-out resistance of a high tenacity polyester strap at low overburden stress of less than 100 kPa was studied with a large-scale pull-out box. Three different types of soil hauled from active construction sites were used. The friction factor, as defined by the ratio of the average failure shear stress to average normal stress, increased with a reduction in the overburden stress. This increase was more significant for the soil with a high dilatancy. 18 refs.

AUSTRALIA
Accession no.706421

Item 75
Journal of Testing & Evaluation
DURABILITY OF GEOSYNTHETICS BASED ON ACCELERATED THERMO-OXIDATION TESTING
Salman A; Goulias D; Elias V
Brooklyn, Polytechnic University; Earth Engineering & Science Inc.
A basic autooxidation scheme was adapted to develop a kinetic model for evaluating the mechanical degradation of geosynthetic materials. Based on experimental data obtained for polyolefin geotextiles (P-3, a needle-punched continuous filament non-woven textile, and P-9, a slit film woven textile), the model provided estimates of strength loss with time caused by thermo-oxidation. The study was restricted to severe conditions of treatment as compared with in-service conditions, to accelerate degradation and to achieve measurable chemical and mechanical changes during two to three years of laboratory incubation time. 16 refs.

USA
Accession no.704895

Item 76
Plastics Extrusion Technology. 2nd edition.
Munich, Hanser Publications, 1997, p.317-40. 82
EXTRUSION OF FILM TAPE
Hensen F; Stausberg G
Barmag Barmer Maschinenfabrik AG
Edited by: Hensen F
Film tapes are uniaxially oriented thermoplastic semi-finished products with a high width-to-thickness ratio, which can be converted into twines, ropes, and knitted or
woven fabrics. Ever since industrial extrusion of film tapes began in 1965, their production has been steadily increasing. Production of the natural fibres jute, sisal and hemp has decreased during the same period; and they have almost completely been replaced by film tapes in some fields of application. This fast growth is explained by the fact that the techniques and production lines in use are more cost-effective than those used with natural products, and are, furthermore, ecologically harmless and energy saving; the raw materials employed are PP and PE - in comparison with the natural products used for the same applications, they have better properties, more stable prices, and are freely available; and applications in packaging, carpets and geotextiles are growing. Aspects covered include development and market significance of film tape extrusion, methods of manufacture, tape characteristics, production methods, design variations of tape lines and automation. 40 refs.

EUROPEAN COMMUNITY; EUROPEAN UNION; GERMANY; WESTERN EUROPE
Accession no.704007

Item 77
Journal of Applied Polymer Science
70, No.11, 12th Dec.1998, p.2097-110
COMPARISON OF THE EFFECTS OF TESTING CONDITIONS AND CHEMICAL EXPOSURE ON GEOMEMBRANES USING THE COMPREHENSIVE TESTING SYSTEM (CTS)
Stessel R I; Barrett W M; Xiaojun Li
South Florida, University

Chemical compatibility tests were conducted on HDPE geomembrane samples using the CTS under low- and high-displacement conditions. CTS development between the two sets of data (low- and high-displacement) was found significantly to reduce the friction within the testing cell. This friction reduction was apparent from the decrease in delta modulus from the larger values obtained during low-displacement testing to the smaller values obtained during high-displacement testing. The results of the high-displacement testing showed statistically insignificant differences between delta modulus results at the 95% confidence interval, which was not possible with the low-displacement test configuration. The high-displacement testing showed that the more soluble the test chemical was in PE, the lower was the resulting delta modulus. 25 refs.

USA
Accession no.702772

Item 78
Geosynthetics International
METHODOLOGY FOR THE EVALUATION OF GEOTEXTILE PORE OPENING SIZES UNDER CONFINING PRESSURE

Palmeira E M; Fannin R J
Brasilia, University; British Columbia, University

A methodology used to evaluate the pore opening sizes of a needle-punched, non-woven polyester geotextile under pressure, using a permeameter subject to vibration, was presented. Particles passing through the geotextiles were collected and analysed to establish a particle size distribution curve. 12 refs.

BRAZIL; CANADA
Accession no.702231

Item 79
Geosynthetics International
MODELLING OF GEOSYNTHETIC REINFORCEMENT IN SOIL RETAINING WALLS
Sawicki A
Polish Academy of Sciences

The behaviour of geosynthetic reinforcement layers in the active and anchorage zones of soil retaining walls was studied. Differential equations that describe the reinforcement layer force/stress distribution, while embedded in soil, were derived for both the elastic and viscoelastic reinforcement layers. The solutions to these differential equations provide a simple method of analysing reinforcement pull-out, the influence of wall facing flexibility on the distribution of forces in the reinforcement, and stress relaxation in reinforcement layers that exhibit creep behaviour. Practical examples were used to illustrate the influence of parameter values on model predictions. 20 refs.

EASTERN EUROPE; POLAND
Accession no.702230

Item 80
Geosynthetics International
CLOGGING OF NON-WOVEN GEOTEXTILES WITH CATTLE MANURE SLURRIES
Barrington S F; El Moueddeb K; Jazestani J; Dussault M
McGill University; Canada, Ministry of Agriculture, Fisheries & Food

Three different types of heat-bonded, needle-punched, non-woven polyester geotextile specimens with similar hydraulic conductivities, but with different O90 values and average pore opening sizes, were exposed to a 3.6 m head of cattle manure slurry containing 7.5% total solids in laboratory columns to test the effect of pore opening size on geotextile specimen clogging. 12 refs.

CANADA
Accession no.702229
**Item 81**

**Geosynthetics International**

**PERFORMANCE OF PROTECTIVE COVER SYSTEMS FOR LANDFILL GEOMEMBRANE LINERS UNDER LONG-TERM MSW LOADING**
Reddy K R; Saichek R E
Illinois, University

Results are presented of large-scale laboratory simulation tests to evaluate the relative performance of different cover systems, consisting of a granular soil layer, i.e. a drainage layer, both with and without the presence of a needle-punched non-woven geotextile, to protect a 1.5 mm thick smooth HDPE geomembrane liner under long-term municipal solid waste loading conditions. Five different granular soils, ranging from a coarse gravel to a medium sand were used in testing. The protective cover system and the geomembrane liner were subjected to incremental loading to a maximum pressure of 1.4 MPa. The effect of long-term loading on the characteristics of the cover soils was assessed by performing particle size analyses, and the physical damage that occurred to the geomembrane liner was visually assessed in addition to performing multi-axial tension, wide strip tension, and water vapour transmission tests. 14 refs.

**USA**
Accession no.702228

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**Item 83**

**Rubber and Plastics News**

**DISTRICT USES SYNTHETIC RUBBER TO LINE LEAKY RESERVOIR**
McNulty M

The use is described of Hypalon synthetic rubber from Du Pont in a lining for the Garvey Reservoir in Monterey Park. The existing structure was leaking due to earthquake damage. The reservoir is said to be the world’s first major installation to use a 90 mil, five ply primary liner made from synthetic rubber. A secondary 36 mil liner was also installed.

**USA**
Accession no.701352

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**Item 84**

**Polymers & Polymer Composites**
6, No.4, 1998, p.205-13

**CHEMICAL RESISTIVITY OF VERY LOW DENSITY PE GEOMEMBRANES. SORPTION/DESORPTION, DIFFUSION AND SWELLING**
Aminabhavi T M; Naik H G
Karnatak University

Data are presented for the sorption, desorption, diffusion and swelling of very low density PE with 14 organic liquids. Sorption results were obtained by a gravimetric method and diffusion coefficients were calculated using Fick’s equation from the initial linear portions of of the sorption/desorption curves. 25 refs.

**INDIA**
Accession no.697316

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**Item 85**

Patent Number: US 5736237 A 19980407

**GEOMEMBRANES**
Rhee A S-J; Nicholas A
Union Carbide Chemicals & Plastics Technology Corp.

A sheet, such as a geomembrane, consists essentially of an extruded in situ blend of two copolymers of ethylene and one or more alpha-olefins having 3 to 8 carbon atoms. The blend has a flow index in the range of about 3 to 100 grams per 10 min., a melt flow ratio in the range of about 50 to 200, a density in the range of 0.905 to 0.943 g/ cu.cm., an Mw/Mn ratio in the range of about 10 to 50 and a weight-average molec.wt. in the range of about 180,000 to 465,000.

**USA**
Accession no.695149
DURABILITY OF POLYETHYLENE-BASED 
GEOMEMBRANES IN AGGRESSIVE LIQUID 
MEDIA
Jakubowicz I; Johansson U
Sweden,National Testing & Research Institute 
(Rapra Technology Ltd.; Plastics & Rubber Weekly; 
European Plastics News)

Ground water is a very valuable resource that must be 
protected from all kinds of contamination. The risk of 
contamination is greatest in connection with transportation 
(roads, railways and airports), industry handling chemicals 
and waste deposits. A way to protect ground water is by 
using membranes as impermeable barriers in the ground. 
One problem that remains is that materials with attractive 
installation properties can be adopted by the industry on 
the basis of a quality specification that has little correlation 
to long-term performance in the field. To avoid this 
problem, it is important to have appropriate test methods 
for a reliable prediction of service life. At present, there 
are only standards available which describe methods for 
testing of short-term compatibility of materials with some 
chemicals. An attempt is made to investigate the influence 
of some frequently-occurring liquid agents on the 
durability of PE-based geomembranes. An accelerated test 
method for prediction of lifetime of geomembranes is 
suggested. Also, various methods for evaluation of 
degradation and failure are used, as the role of such 
methods is critical in the effectiveness of a durability 
testing programme. 6 refs.

MARKETING TYRE SHREDS AS PLAYGROUND 
COVER
Recycled Rubber Resources was formed to produce a coloured 
rubber surfacing product. Boing! comprises of shredded tyres 
coLOURED WITH A NON-TOXIC COATING. While playgrounds are a 
primary market for the product, other applications include 
horse arenas, golf courses and athletic fields. 
RECYCLED RUBBER RESOURCES INC. 
USA

ESTIMATION OF DYNAMIC INTERFACIAL 
PROPERTIES OF GEOSYNTHETICS
De A; Zimmie T F
GeoSyntec Consultants; Rensselaer Polytechnic 
Institute

Laboratory test results on eight different interfaces, 
formed through various combinations of three 
geosynthetics (a geotextile, a smooth geomembrane, and 
a geonet), are presented and discussed. The dynamic 
frictional properties were estimated using cyclic direct 
shale tests, shaking table tests conducted at a normal g-
level of 1g as well as high g-levels, and on a 100 g-ton 
geotechnical centrifuge. The centrifuge simulated high 
normal stress levels, commonly encountered by 
geosynthetics comprising base liners of landfills or base 
isolators for large structures. 17 refs.

SIMPLIFIED SEISMIC DESIGN PROCEDURE 
FOR GEOSYNTHETIC-LINED, SOLID-WASTE 
LANDFILLS
Bray J D; Rathje E M; Augello A J; Merry S M 
California,University; Texas,University; Haley & 
Aldrich; Utah,University

A critical review is presented of seismic design practices 
in light of the observed performance of landfills during 
recent earthquakes. Developments in these areas are 
summarised: earthquake ground motions, dynamic waste 
fill properties, dynamic responses of geomembranes and 
their interfaces, non-linear dynamic response analysis, and 
seismic stability evaluation. A newly developed simplified 
seismic analysis procedure that requires the most critical 
Factors to be addressed during a seismic performance 
evaluation is presented. The underlying seismic analysis 
procedure was validated against observed performance 
of landfills shaken by the 1989 Loma Prieta and 1994 
Northridge, California earthquakes. 65 refs.

USA
Accession no.689483

A Critical Review of Seismic Design Practices 
for Geosynthetic-Lined, Solid-Waste 
Landfills
Bray J D; Rathje E M; Augello A J; Merry S M 
California,University; Texas,University; Haley & 
Aldrich; Utah,University

A critical review is presented of seismic design practices 
in light of the observed performance of landfills during 
recent earthquakes. Developments in these areas are 
summarised: earthquake ground motions, dynamic waste 
fill properties, dynamic responses of geomembranes and 
their interfaces, non-linear dynamic response analysis, and 
seismic stability evaluation. A newly developed simplified 
seismic analysis procedure that requires the most critical 
Factors to be addressed during a seismic performance 
evaluation is presented. The underlying seismic analysis 
procedure was validated against observed performance 
of landfills shaken by the 1989 Loma Prieta and 1994 
Northridge, California earthquakes. 65 refs.

USA
Eight papers presented on day one of the Polymer Testing ’97 conference. Topics covered include a novel method for rapid determination of microbial growth on plastics, durability of polyethylene based geomembranes in aggressive liquid media, measurement of environmental stress cracking of plastics and the influence of acid precipitations on weathering results.

Accession no.682037

Item 94

Patent Number: US 5696174 A 19971209

STABLE AND WATER-RESISTANT AQUEOUS FOAM COMPOSITION

Chao Y-Y H; Chao K-J

Allied Foam Tech Corp.

This contains a long chain cationic organic compound and a long-chain anionic organic compound in a weight ratio of from 0.05:1 to 15:1. It may be mixed with various water-soluble or water-dispersible organic, polymeric or inorganic substances and used in applications where lightweight, heat, sound or other insulative, barrier properties or homogeneous material distribution are required. Such applications include cementitious or gypsum containing substances, adhesives, binders, paper treating materials, coatings, ceramics, landfills, geofills and firefighting and fireproofing materials.

USA

Accession no.683806

Item 95


BIOMAX HYDRO/BIODEGRADABLE POLYESTER RESIN

Ferretti D

Du Pont de Nemours E.I.,& Co.Inc.

DuPont has created a new family of highly versatile polymers, called Biomax hydro/biodegradable polyester resin, that decomposes without harm to the soil or environment. Based on PETP technology, Biomax can be made into film, fibre and non-wovens, as well as being thermoformed and injection moulded. Potential applications range from geotextiles to agricultural materials and packaging. Biomax can be recycled, incinerated or landfilled, but is intended mainly for disposal by composting and in-soil degradation. In all tests, Biomax proves harmless to the environment at every stage of the decomposition process and virtually undetectable to the unaided eye in about eight weeks. It has a high melting point for a degradable material, which opens up a wide range of processing options. Product properties are diverse and customisable.

USA

Accession no.679263
Item 96
Polyolefins X. Conference proceedings.

INTERACTIONS OF HINDERED AMINE STABILISERS - IN ACIDIC AND ALKALINE ENVIRONMENTS
Keck-Antoine K; Koch H; Scharf D
Hoechst Celanese Corp.; Hoechst AG
(SPE,South Texas Section; SPE,Thermoplastic Materials & Foams Div.)

Hindered amine stabilisers (HAS) are very effective UV and thermal stabilisers. As a result of their chemical structure the alkalinity of HAS varies significantly, causing antagonistic interactions in the presence of acids. These interactions can result not only in reduced light stability performance, but also in inferior long-term thermal stability and severe processing problems. In a non-acid environment, the alkalinity of HAS itself can create a sufficiently alkaline environment resulting in performance diminishing side reactions. The higher the alkalinity of the HAS structure the more pronounced these interactions. 10 refs.

EUROPEAN COMMUNITY; EUROPEAN UNION; GERMANY; USA; WESTERN EUROPE
Accession no.674877

Item 97
Journal of Applied Polymer Science
67, No.11, 14th March 1998, p.1885-9

MODELLING DIFFUSION THROUGH GEOMEMBRANES
Chan Man Fong C F; Moresoli C; Xiao S; Li Y; Bovenkamp J; de Kee D
Tulane,University; Sherbrooke,University; Oriclor Inc.; Canada,Defence Research Establishment Suffield

A phenomenological model that incorporates swelling was adopted and used to solve the one-dimensional sorption problem. The model predictions were in good agreement with experimental data, involving the transport of dichloromethane, trichloroethylene, and benzene through HDPE and PVC geomembranes. The theoretical curves predicted weight gain and flux time profiles, including the case where the flux went through a maximum. 7 refs.

CANADA; USA
Accession no.671238

Item 98
Journal of Testing & Evaluation
25, No.6, Nov.1997, p.576-83

LOCAL VERSUS GLOBAL STRAIN MEASUREMENT OF POLYMERIC GEOGRID
Perkins S W; Schultz J L; Lapeyre J A
Montana,State University; Bridge Diagnostics Inc.

Polymeric geogrids consisting of a planar polymeric material with a grid-like configuration have become increasingly popular as a reinforcement inclusion in soil structures. As the use of geogrid materials has increased, so has the need to quantify both the in-air and in-soil mechanical behaviour. Bonded resistance strain gauges have been used to quantify the strain response of geogrids. Problems associated with gauge mounting, bonding, and environmental protection must be addressed. The relationship between the local measured strain and the global strain must be established. These issues are addressed by conducting in-air tension tests on a particular geogrid. In general, it has been found that strain gauges can be successfully bonded to the ribs of geogrids such that strains up to 7% can be recorded. These gauges are successfully protected and used in a field application for a period of five months. Strains measured along the ribs of the geogrids are seen to be 1.25 to 1.6 times the average strain applied across the specimen for monotonic loading, The two strains correspond nearly one-for-one for cyclic loading. The presence of the strain gauge and accompanying cement appears to have little effect on the strain response. 9 refs.

USA
Accession no.670421

Item 99
Scrap Tire News

WORKING ON THE MARKETS
Ethan Grove started his involvement with crumb rubber fifteen years ago mixing roofing formulations in a Baltimore warehouse. Today, he’s mixing on a larger scale. As a joint venture partner in Enviro-Flex, a Baltimore-based manufacturer of rubber roofing, Grove is getting his products into markets worldwide, and, as a principal of Elastomeric Technologies - a product design and development company in Clinton, MD, he is introducing a mini paver that can introduce recycled rubber to more applications. While crumb rubber producers fret over processing and sizing, Grove is benefiting from a decision years ago to concentrate on finding ways to use the ground rubber. Just a few months ago, the state of Maryland approved EnviroFlex’s coating products for landfill liner use opening the door for new applications for the company’s products. Enviro-Flex’s landfill liner mats consist of a geotextile membrane overlaid with an impermeable rubber coating that contains 30% crumb rubber. More recently, Grove perfected a polyester joint seal compound for the liners making them 100% waterproof. Details are given.

ELASTOMERIC TECHNOLOGIES; ENVIRO-FLEX
USA
Accession no.670360

Item 100
Geotextiles and Geomembranes
14, No.12, Dec.1996, p.647-726

...
FIRST GERMANY/USA GEOMEMBRANE WORKSHOP
Corbet S P; Peters M
Maunsell G, & Partners Ltd.

The first Germany/USA Geomembrane Workshop was held at the BAM, Berlin in June 1996. The main objects were to advance the understanding of geomembrane performance, to provide guidance for regulators writing landfill liner regulations and to provide guidance for design engineers new to the industry. Details are given.

EUROPEAN COMMUNITY; EUROPEAN UNION; UK; WESTERN EUROPE
Accession no.670353

Item 101
Geosynthetics International
4, No.5, 1997, p.542-6
DISCUSSIONS AND CLOSURE. FIELD EVALUATION OF PROTECTIVE COVERS FOR LANDFILL GEOMEMBRANE LINERS UNDER CONSTRUCTION LOADING
Thiel R S; Babu-Tweneboah K; Giroud J P; Carlson D S; Schmertmann G R; Reddy K R; Bandi S R; Rohr J J; Finy M; Siebken J
GeoSyntec Consultants; Thiel Engineering

Discussions are presented of the technical note on 'Field Evaluation of Protective Covers for Landfill Geomembrane Liners under Construction Loading' by Reddy, Bani, Rohr, Finy and Siebken (ibid, 3, No.6, 1996, p.679-700). A response by Reddy et al. is also given. 3 refs.

USA
Accession no.666782

Item 102
Geosynthetics International
4, No.5, 1997, p.509-21
LOAD TRANSFER MECHANISM IN PULL-OUT TESTS
Alobaidi I M; Hoare D J; Ghataora G S
Birmingham, University

A numerical method for prediction of soil-geotextile interface friction parameters was developed. A strain softening model was used to simulate the relationship between shear stress and horizontal displacement at the soil-geotextile interface. Pull-out tests were performed on two types of geotextile (polyester and PP), with different tensile stiffnesses, embedded in a granular soil. For each geotextile, pull-out tests were performed at confining pressures of 20, 50, 100 and 200 kPa. It was found that, unless breakage of the geotextile occurred, the peak pull-out force occurred after a small displacement of the free end of the geotextile. At the peak pull-out force, the maximum shear stress occurred near the free end of the geotextile, while the shear stress at the loaded end was at or near a residual value. The use of an average friction angle overestimated pull-out resistance. The numerical technique developed provided more accurate values for soil-geotextile interface friction parameters. 11 refs.

EUROPEAN COMMUNITY; EUROPEAN UNION; UK; WESTERN EUROPE
Accession no.666781

Item 103
Geosynthetics International
4, No.5, 1997, p.481-508
MECHANICAL BEHAVIOR OF SAND REINFORCED WITH MESH ELEMENTS
Morel J C; Gourc J P
Ecole Nationale des Travaux Publics de l’Etat; Grenoble, Joseph Fourier University

The shear strength of sand reinforced with randomly-oriented and vertically-aligned PP mesh elements was studied. A biaxial apparatus was designed to load specimens under plane strain conditions and photogrammetry was used to measure the strain field within the specimens during loading. The biaxial test results obtained for sand specimens reinforced with randomly-oriented mesh elements illustrated the effect of reinforcement content on specimen strength. Strain localisation was observed for both reinforced and unreinforced sand specimens but, for the reinforced sand specimens, the strain localisation phenomenon was not accompanied by a drop in strength. Further testing was performed using a large shear box to impose a fixed shear plane in the reinforced specimens. Sand specimens with randomly-oriented mesh elements, as well as sand reinforced with vertically-aligned mesh elements, were tested in the large shear box. 28 refs.

EUROPEAN COMMUNITY; EUROPEAN UNION; FRANCE; WESTERN EUROPE
Accession no.666780

Item 104
Geosynthetics International
4, No.5, 1997, p.463-79
CREEP AND STRESS RELAXATION OF GEOGRIDS
Leshchinsky D; Dechasakulsom M; Kaliakin V N; Ling H I
Delaware, University

Results of a preliminary experimental attempt to identify the stress relaxation behaviour of nine typical geogrids used to reinforce soil structures are presented. A simple test method that directly measured the stress relaxation of geogrids was developed. The geogrids were subjected to initial loads of 40, 60 and 80% of their ultimate short-term strengths. Each test was carried out for a period of one month, or until creep rupture occurred, whichever was shortest. The maximum potential stress relaxation was approximately 30% of the initial load for PETP geogrids and 50% for HDPE geogrids. 20 refs.

USA
Accession no.666779

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Item 105

Geosynthetics International
4, No.6, 1997, p.661-72

WATER RETENTION FUNCTIONS OF FOUR NONWOVEN PP GEOTEXTILES
Stormont J C; Henry K S; Evans T M
New Mexico,University; US,Army; GeoSyntec Consultants
The water retention functions of four nonwoven PP geotextiles were measured. Water retention functions were found to be hysteretic. 11 refs.
USA
Accession no.666589

Item 106

Geosynthetics International
4, No.6, 1997, p.645-59

SHEAR BEHAVIOUR OF AN UNREINFORCED GEOSYNTHETIC CLAY LINER
Eid H T; Stark T D
Illinois,University
Dry and hydrated specimens of an unreinforced HDPE geomembrane-backed geosynthetic clay liner were sheared against a textured geomembrane using a torsional ring shear apparatus to study the shear behaviour of geomembrane encapsulated bentonite. The effects of hydration and normal stress application on unreinforced geomembrane-backed geosynthetic clay liner/textured geomembrane interface shear strength are discussed. 13 refs.
USA
Accession no.666588

Item 107

Geosynthetics International
4, No.6, 1997, p.623-43

INTERACTION BETWEEN TYRE SHREDS, RUBBER-SAND AND GEOSYNTHETICS
Bernal A; Salgado R; Swan R H; Lovell C W
GeoHidra; Purdue University; GeoSyntec Consultants
Details are given of a test programme consisting of direct shear tests, interface direct shear tests, and geosynthetic pull-out tests to determine the interaction properties of tyre shreds and rubber-sand fills with three different flexible geogrids and a woven geotextile. Data on the testing programme, test results, and conclusions based on the results are discussed. 14 refs.
USA
Accession no.666587

IN FLEXIBLE PAVEMENTS. II.
Perkins S W; Ismeik M
Montana,State University
Details are given of the use of geosynthetics to reinforce the base course layer of flexible pavements. A review is presented of existing design techniques developed for this application. Analytical studies using finite element techniques to predict roadway response and to illustrate reinforcement mechanisms are summarised. 33 refs.
USA
Accession no.666586

Item 109

Geosynthetics International
4, No.6, 1997, p.549-604

SYNTHESIS AND EVALUATION OF GEOSYNTHETIC-REINFORCED BASE LAYERS IN FLEXIBLE PAVEMENTS. I.
Perkins S W; Ismeik M
Montana,State University
Details are given of the use of geosynthetics to reinforce the base course layer of flexible pavements. Studies are described involving laboratory-scale experiments using stationary cyclic loads or moving wheel loads and field studies using controlled vehicle loads or random traffic loads. 38 refs.
USA
Accession no.666585

Item 110

Polymers & Polymer Composites
5, No.5, 1997, p.353-8

DURABILITY OF POLYETHYLENE-BASED GEOMEMBRANES IN AGGRESSIVE LIQUID MEDIA
Jakubowicz I; Johansson U
Sweden,National Testing & Research Institute
The need for appropriate test methods for the reliable prediction of service life of a geomembrane material for waste containment has led to a research project to investigate the influence of some frequently occurring liquid agents on the durability of PE-based geomembranes. An accelerated test method for predicting the lifetime of geomembranes is also suggested. Tests were carried out as to durability in metal ions solution, chloride ions solution and synthetic diesel oil. 6 refs.
SCANDINAVIA; SWEDEN; WESTERN EUROPE
Accession no.664202

Item 111

Macplas International
May 1997, p.50-1

MARKET PERSPECTIVES FOR POLYOLEFIN TEXTILES
Peckstadt J
European Association for Textile Polyolefins

The importance of polyolefins in textile applications is discussed, with particular reference to polypropylene. Polyolefin textiles represent 28% of the total use of polyolefins, and PP accounts for 95% of polyolefin consumption in textiles. Growth rates and trends are examined, and include increases of polyolefin textiles in the manufacture of flexible intermediate bulk containers, clothing, in the hygiene sector, in strapping, and medical sector twines, and a slow decrease in agrotextiles, geotextiles and construction textiles, together with a decrease in sacks, ropes and floor coverings is noted. A statistical analysis is included of the industry.

EUROPE-GENERAL
Accession no.662624

Item 112
PRODUCTION OF HIGH TENACITY TAPES FROM WASTE POLYPROPYLENE
Ghosh S; Horrocks A R
Charlottesville, Institute of Textile Technology; Bolton Institute
Edited by: Horrocks A R
(Bolton Institute; British Textile Technology Group)

The area of technical textiles, where aesthetics are of less consequence than in other textile sectors, offers the opportunity to create fibres and tapes having first grade properties if the physics and chemistry of recycled polymer and its conversion are understood. Of particular interest is the field of geotextiles (textiles used in civil engineering) where the annual world market for geotextiles is approaching 1,000 million sq.m., or about 250,000 tonnes of raw materials, of which over 70% comprises PP. During the extrusion of component fibres and tapes, up to 10% by weight of process waste polymer is introduced without noticeable affects on quality. There is a desire by producers to increase the amount of blended recycled PP and even include PE with virgin polymer during the extrusion process. In this way, they can fully re-use their own wastes, supplement them by including wastes from other sources and so replace virgin PP by cheaper, recycled polymer. Sources of non-processor waste may include PP granules from recycled car battery housing and industrial film waste, for example. The effects that added polyolefin waste has on the tensile, physical and chemical properties of orientated PP tapes are studied, analysing the effects that adding large proportions of waste has on the properties of orientated PP tapes. 10 refs.
EUROPE-GENERAL
Accession no.661762

Item 114
European Plastics News
24, No.11, Dec.1997, p.28
PE LAGOON LINERS HELP TO IMPROVE IRRIGATION AT NURSERY
A large nursery in the UK has recently commissioned an irrigation lagoon that uses a multi-layered membrane from Monarflex Geomembranes. Blackline 750 is a low density PE material that is made from three separate films that combine to form a 0.75mm membrane, it is briefly reported.
MONARFLEX
EUROPEAN COMMUNITY; EUROPEAN UNION; UK; WESTERN EUROPE
Accession no.661693

Item 115
Journal of Applied Polymer Science
65, No.9, 29th Aug.1997, p.1833-6
SORPTION AND PERMEATION OF ORGANIC CONTAMINANTS THROUGH HIGH-DENSITY POLYETHYLENE GEOMEMBRANES
Xiao S; Moresoli C; Bovenkamp J; De Kee D
Sherbrooke, University; Canada, Defence Research Establishment
Geomembranes are used as liners to protect the environment from hazardous toxic contaminants. HDPE represents 40-45% of the raw material used in the manufacture of geomembranes. Although geomembranes are rarely exposed to pure contaminants, surprisingly little research has been conducted using multi-component systems in contact with geomembranes. Breakthrough times and the associated fluxes have been investigated previously as a result of membrane-mixture contact. The substantial effect of mixture transport through PVC membranes has also been reported. An experimental study involving the transport of a mixture of penetrants through HDPE geomembranes is further reported. 14 refs.

Item 116
Asian Plastics News
April 1997, p.19-20
SUCCESSFUL SHEET
Wong G

The production of PE geomembrane sheet by CT Petrochemical for use in lining ponds, reservoirs, landfills, waste water treatment areas, etc., is described. The company has recently commissioned a turnkey blown film line from Battenfeld Gloucester to make special grade geomembrane sheet from HDPE in smooth and textured forms. The production line is described, together with the product and methods of joining the geomembrane sheets. The activities of CT Petrochemical’s sister companies are also indicated.

CP GROUP; CT PETROCHEMICAL; BATTENFELD GLOUCESTER ENGINEERING CO.INC.
THAILAND; USA
Accession no.652537

Item 117
Scrap Tire News
11, No.8, Aug.1997, p.5
INDUSTRY-GOVERNMENT PARTNERSHIP ISSUES DESIGN GUIDELINES FOR TYRE SHRED FILL PROJECTS

A joint industry-government partnership is reported to have issued technical recommendations in July designed to minimise internal heating of tyre shred fills. The recommendations, Design Guidelines To Minimize Internal Heating of Tire Shred Fills, were developed by the Ad Hoc Civil Engineering Committee, which was formed in April 1995 to address possible causes of internal heating reactions that occurred at three tyre shred fill projects in 1995. The guidelines are the result of investigation into more than 70 successful tyre shred fill projects. The guidelines were developed to incorporate design and engineering criteria for two classes of tyre shred fills: Class I, up to 1 m in depth, and Class II, greater than 1 m, up to 3 m in depth. Tyre chip size, chip cleanliness, exposed wire, fill access to water and air, geotextile covering and cover fill material are among the criteria addressed in the guidelines. Details are given.

AD HOC CIVIL ENGINEERING COMMITTEE; SCRAP TIRE MANAGEMENT COUNCIL; TIRE & RUBBER RECYCLING ADVISORY COUNCIL USA
Accession no.651673

Item 118
Geosynthetics International
4, No.2, 1997, p.137-63
FINITE ELEMENT MODELLING OF INELASTIC DEFORMATION OF DUCTILE POLYMERS
Zhang C; Moore I D
Western Ontario,University

Two uniaxial constitutive models were extended to provide a multi-axial formulation which was implemented in a finite element program. Finite element simulations of a perforated HDPE plate under remote uniaxial loading were performed as well as an HDPE pipe section under parallel plate loading. Results were compared with measured experimental results. 22 refs.

Canada
Accession no.649559

Item 119
Geosynthetics International
4, No.2, 1997, p.81-136
GEOSYNTHETIC-REINFORCED SOIL RETAINING WALLS AS IMPORTANT PERMANENT STRUCTURES. 1996-1997 MERCER LECTURE
Tatsuoka F; Tateyama M; Uchimura T; Koseki J
Tokyo,University

A review is presented of the use of geosynthetic-reinforced soil retaining walls for railway embankments, bridge abutments, and walls to support rail tracks. A new method of stiffening reinforced soil by vertical preloading and prestressing is also described. 41 refs.

Japan
Accession no.649558

Item 120
Toronto,27th April-2nd May 1997,p.3366-70. 012
CALCULATING THERMAL INDUCED STRESSES USING NONLINEAR VISCOELASTIC MATERIAL MODEL
Schloeele N; Schmachtenberg E
Essen,University (SPE)

The application of a nonlinear viscoelastic material model to the calculation of thermal stresses in geomembranes is presented. The model’s parameters as well as the
temperature depending calibration are described. Comparing measurements with the simulation, it is shown that the model is capable of a good prediction of the stress curves. Thermal cycling is applied to a HDPE material under two different strains. Both load cases lead to significant tensile stress in the material. 7 refs.

EUROPEAN COMMUNITY; EUROPEAN UNION; GERMANY; WESTERN EUROPE
Accession no.639889

Item 121

CHEMICAL COMPATIBILITY OF GEOMEMBRANES - SORPTION, DIFFUSION AND SWELLING PHENOMENA
Aminabhavi T M; Naik H G; Donaldson J; Siebken J R Karnatak University; National Seal Co. (SPE)

Sorption, diffusion and permeation of aromatic liquids into HDPE, LLDPE, VLDPE and PP geomembranes are presented at 25, 50 and 70 deg.C. Diffusion coefficients are calculated using Fick’s equation and swelling of the geomembranes is measured by monitoring the increase in volume. Results of this research may be useful in the selection of a suitable geomembrane for a specific application. 6 refs.

INDIA; USA
Accession no.638263

Item 122
Plastics World 54, No.3, March 1996, p.35/8

SOLID FORM VITAMIN E

The new granular Ronotec 201 from Hoffmann-LaRoche is said to offer all the benefits of the liquid Vitamin E stabiliser system. It is low-dusting, has good flow characteristics and disperses easily. BASF has introduced an antioxidant based on its original vitamin E product, but with much greater hydrolysis resistance. A line of highly loaded antioxidant formulations from Colortech is aimed at wire and cable, geomembrane and resin recycling applications. Colortech 10604-11 contains a proprietary blend of high molecular weight hindered phenolic antioxidant and phosphite process stabiliser.

HOFFMANN-LA ROCHE INC.; BASF CORP.; COLORTECH CORP.
CANADA; USA
Accession no.634023

Item 123
Canadian Plastics 55, No.3, April 1997, p.27-30

FILMS FOR THE FUTURE
LeGault M

The activities of two Canadian producers of geomembranes are reported. Firstly, Columbia Geosystems manufactures PE sheeting slit and wound into 23 feet rolls for use in containment applications, such as landfills, mining, ponds and water treatment applications.. The company produces single layer smooth and three-layered textured sheeting. Secondly, Solmax Geosynthetiques is to make the change from being an installer of geomembranes to a manufacturer, and will pursue strategic alliances in order to enhance the company’s entry into new markets, it is reported.

COLUMBIA GEOSYSTEMS; SOLMAX GEOSYNTHETIQUES; SOLMAX INTERNATIONAL INC.
CANADA
Accession no.636899

Item 124

GEOGRID COMPOSED OF POLYETHYLENE TEREPHTHALATE AND POLYOLEFIN BICOMPONENT FIBRES AND PROCESS FOR THE PREPARATION THEREOF
Harford D W
Hoechst Celanese Corp.

Warp knit, weft inserted geogrid fabric without a topcoat is made by passing PETP having an intrinsic viscosity of at least 0.89 decilitres per gram, as determined from a solvent base of orthochlorophenol at 25C, in a molten state into an apparatus for spinning bicomponent sheath-core filaments to form the core of each filament of a bicomponent fibre, passing an adhesive polyolefin in a molten state containing about 0.5 to 2 wt.% carbon black into the apparatus to form a sheath about the core of each filament of the bicomponent fibre, passing and drawing the bicomponent fibre, applying a finish at a level of about 0.4 to 0.8 wt.% to the bicomponent fibre, sizing and warping the bicomponent fibre, weaving or knitting the bicomponent fibre into a fabric and bonding the fabric by fusing the sheath using a heating medium.

USA
Accession no.637585

Item 125
Geosynthetics International 4, No.1, 1997, p.65-79

STRENGTH AND DEFORMATION PROPERTIES OF SOILS REINFORCED WITH FIBRILLATED FIBRES
Nataraj M S; McManis K L
New Orleans,University

Results of preliminary laboratory tests on a clay and a sand reinforced with randomly distributed PP fibrillated fibres are presented. Results of compaction, direct shear, unconfined compression and California Bearing Ratio tests are described. The influence of normal stress, the
amount of reinforcement, specimen size, and moisture content are discussed. 13 refs.
USA
Accession no.633585

Item 126
Geosynthetics International
4, No.1, 1997, p.51-64
CRITICAL PARAMETERS FOR SPECIFICATION OF PREFABRICATED VERTICAL DRAINS
Rawes B C
Akzo Nobel Geosynthetics
Details are given of the critical parameters for the specification of prefabricated vertical drains with reference to the ASTM D 4716 test method for measuring discharge capacity. A suggested model specification is given. 13 refs.
EUROPEAN COMMUNITY; EUROPEAN UNION; NETHERLANDS; WESTERN EUROPE
Accession no.633584

Item 127
Geosynthetics International
4, No.1, 1997, p.33-50
POLYMER GEOGRIDS FOR BRIDGING MINING Voids
Bridle R J; Jenner C G
Wales,University
Details are given of full-scale field tests to determine the support provided by polymer geogrids in typical road construction over old coal mining areas. A number of analytical methods were defined and combined to develop an appropriate design approach that matches the measured field results as closely as possible. 3 refs.
EUROPEAN COMMUNITY; EUROPEAN UNION; UK; WESTERN EUROPE
Accession no.633583

Item 128
Geosynthetics International
4, No.1, 1997, p.11-32
IN-ISOLATION STRAIN MEASUREMENT OF GEOSYNTHETICS IN WIDE-WIDTH STRIP TENSION TEST
Perkins S W; Lapeyre J A
Montana,State University
Details are given of the construction of a large wide-width strip tension apparatus to test the differences between the global and measured strain for four different types of strain sensors attached to geogrid and geotextile specimens. Calibration factors were developed and applied to the results to achieve a match between the measured and global strains. 17 refs.
USA
Accession no.633582

Item 129
Fibres & Textiles in Eastern Europe
5, No.1, Jan./March 1997, p.26
GEOTEXTILES PRODUCERS ASSOCIATION
A list is given of the twelve members of the Polish Geotextile Producers Association. A table is also given showing the applications of geotextile products in geotextile services offered by Polish producers.
EASTERN EUROPE; POLAND
Accession no.633582

Item 130
Geosynthetics International
3, No.6, 1996, p.771-86
SHEAR BEHAVIOUR OF REINFORCED GEOSYNTHETIC CLAY LINERS
Stark T D; Eid H T
Illinois,University
Ring shear tests were performed to evaluate the effect of bentonite on the interfacial shear strength between a geomembrane and a reinforced geosynthetic clay liner (GCL) and the internal shear behaviour of reinforced GCLs. The tests yielded an interfacial shear strength that is in agreement with the back-calculated shear strength values from two test pads. Recommendations are presented for the rate of shear that should be used for internal shear testing of GCLs. 18 refs.
USA
Accession no.632425

Item 131
Geosynthetics International
3, No.6, 1996, p.741-69
WATER DIFFUSION THROUGH GEOMEMBRANES UNDER HYDRAULIC PRESSURE
Eloy-Giorni C; Pelte T; Pierson P; Margrita R
AGRU Environnement France; GeoSyntec Consultants; Fourier J.,Universite; Grenoble,Centre d’Etudes Nucleaires
A theoretical analysis of fluid transport mechanisms through geomembranes is presented. Diffusion and permeation tests that use a volumetric and radioactive tracer method to measure the amount of water flow through geomembrane specimens give an understanding of the mechanism of water transport through HDPE, PVC and bituminous membranes. The use of the hydraulic permeation test and hydraulic conductivity (as defined by Darcy’s law) to characterise geomembrane permeability are discussed. 14 refs.
EUROPEAN COMMUNITY; EUROPEAN UNION; FRANCE; USA; WESTERN EUROPE
Accession no.632424
Item 132
Geosynthetics International
3, No.6, 1996, p.701-19
ROLE OF SPECIMEN GEOMETRY, SOIL HEIGHT AND SLEEVE LENGTH ON THE PULL-OUT BEHAVIOUR OF GEOGRIDS
Lopes M L; Ladeira M
Porto, Universidade

Pull-out test results of geogrid specimens embedded in a granular soil are presented. The influence of specimen geometry, soil height and sleeve length on the pull-out force of the geogrid specimen was discussed and the results of nine pull-out tests were analysed. Soil and geogrid properties were also fully described and the soil-geogrid interaction behaviour was studied. 7 refs.
EUROPEAN COMMUNITY; EUROPEAN UNION; PORTUGAL; WESTERN EUROPE
Accession no.632165

Item 133
Geosynthetics International
3, No.6, 1996, p.679-700
FIELD EVALUATION OF PROTECTIVE COVERS FOR LANDFILL GEOMEMBRANE LINER UNDER CONSTRUCTION LOADING
Reddy K R; Bandi S R; Rohr J J; Finy M; Siebken J
Illinois University; Great Lakes Soil & Environmental Consultants Inc.; Rust Environment & Infrastructure; Waste Management Inc.; National Seal Co.

The performance of landfill geomembrane liner protective cover systems with and without a geotextile was evaluated using field tests. The physical properties of the protective cover soils and the geomembrane liner before and after field testing were determined using laboratory tests. The hydraulic properties of the geomembrane field samples were measured using water vapour transmission tests, and the mechanical properties were measured using multi-axial tension tests and wide strip tensile tests. A low mass per unit area geotextile was demonstrated to completely protect the geomembrane in this study. 12 refs.
USA
Accession no.632423

Item 134
Rubber and Plastics News 2
18, No.11, 3rd March 1997, p.4
FEW CAN COMPARE WITH ATLANTIC WASTE’S SHREDDED TYRE USAGE
Slaybaugh C

Atlantic Waste Disposal uses shredded tyres for several civil engineering applications including “daily” and “alternate daily cover” for landfills. The landfill operation located south of Richmond, Va., is a “recirculating landfill” in which leachate is captured by a plastic liner at the bottom of the fill, then piped back to the surface where it is allowed to filter back down through the mass of debris. This encourages production of methane or landfill gas which Atlantic Waste hopes one day to harvest and use for fuel.
ATLANTIC WASTE DISPOSAL INC.
USA
Accession no.632165

Item 135
Plastics and Rubber Asia
12, No.70, April 1997, p.30-1
FROM PRAWN FARMER TO FILM STAR
Pilling M

CT Petrochemical is reported to have established a coextrusion geomembrane film production plant to supply the needs of a prawn farming sister company. The CP Group diversified into the plastics business several years ago, forming Charoen Pokphand Petrochemical (CPP). This company in turn set up CT Petrochemical to produce geomembrane film to supply its own needs. The geomembrane film production operation, including the blown film line, materials handling, silos and cranes were all supplied in a turnkey package by Battenfeld Gloucester; investment has totalled around six million US dollars, with 3.75 million US dollars for the three-layer coextrusion blown film line. Details are given.
CT PETROCHEMICAL CO.LTD.; CHAROEN POKPHAND PETROCHEMICAL CO.LTD.
INDONESIA
Accession no.631955

Item 136
Plastics and Rubber Weekly
No.1683, 25th April 1997, p.9
FROM LAB TO LECTERN

Durability of plastics was the theme chosen for the first day of Polymer Testing 97 held at Rapra Technology. It is estimated that in the diagnosis of some 5000 plastics product failures, about 99% were of the brittle fracture type. Subjects covered at the conference included a novel method for the rapid determination of microbial growth of plastics, scratch resistance of polymers, durability of PE-based geomembranes in aggressive liquid media, the influence of acid rain on weathering results and chemical analysis.
RAPRA TECHNOLOGY LTD.
EUROPEAN COMMUNITY; EUROPEAN UNION; UK; WESTERN EUROPE
Accession no.631484

Item 137
Plastics World
STRONG GEOMEMBRANE MARKET’S NOT FOR FAINT OF HEART
Callari J
Companies in the geomembrane market are generally part film extruder, part construction company. Mastio targets geomembranes as one of the top five fastest-growing markets for film and is projecting double-digit average annual growth for the next five years. Solmax Geosynthetiques, based in Quebec, recently entered the processing end of the business with the purchase of a three-layer blown film line. Most of the very recent installations have been of the coex/blown variety.

MASTIO & CO.
NORTH AMERICA
Accession no.628620

**Item 138**
Journal of Applied Polymer Science
63, No.9, 28th Feb.1997, p.1189-97
SORPTION AND PERMEATION OF ORGANIC ENVIRONMENTAL CONTAMINANTS THROUGH PVC GEOMEMBRANES
Xiao S; Moresoli C; Bovenkamp J; De Kee D
Sherbrooke,University; Canada,Defence Research Establishment

The effect of the diffusion of penetrants (benzene, dichloromethane and trichloroethylene) on the barrier properties of PVC geomembranes was studied. The membranes experienced swelling to a degree which depended on the type of penetrant used. The diffusion coefficients and breakthrough times obeyed an Arrhenius-type relation over the temperature range studied. Liquid sorption of the penetrants modified the geomembrane structure. Surface pretreatment of the membranes with different contaminants influenced the subsequent transport of organic penetrants. The induced swelling as a result of contact with one penetrant was likely to alter the system free volume, allowing for a different rate of mass transport for subsequent penetrants. 15 refs.

CANADA
Accession no.624407

**Item 139**
Geosynthetics International
3, No.5, 1996, p.605-75
PUNCTURE PROTECTION OF GEOMEMBRANES. III. EXAMPLES
Koerner R M; Wilson-Fahmy R F; Narejo D
Drexel,University; Parsons Brinckerhoff; Carleton,University

The design developed in part II (ibid, p.629-53) is used to provide several numerical examples that highlight the different strategies used in Germany and in the USA for the selection of protection geotextiles. A number of design charts for a wide variety of practical situations is included. Puncture resistance results for a geomembrane with different types of protection materials (other than virgin polymer non-woven needle-punched geotextiles) are presented. The design procedures presented are shown to result in a site-specific and material-specific factor of safety. 11 refs.

USA
Accession no.622412

**Item 140**
Geosynthetics International
3, No.5, 1996, p.629-53
PUNCTURE PROTECTION OF GEOMEMBRANES. II. EXPERIMENTAL
Narejo D; Koerner R M; Wilson-Fahmy R F
Carleton,University; Drexel,University; Parsons Brinckerhoff

Truncated cone and stone puncture test results for geomembrane protection materials are presented for both short and long term durations. Materials studied are a 1.5mm thick HDPE geomembrane and various non-woven needle-punched geotextiles with varying masses per unit area made from virgin polyester and PP continuous and staple fibres. Using the results of this testing programme, a design methodology is developed for calculating the required mass per unit area of a puncture protection material for a given factor of safety. Conversely, the design can be used to determine the unknown factor of safety for a given type of protection material. 17 refs. (Pt.I, ibid, p.605-28)

USA
Accession no.622411

**Item 141**
Geosynthetics International
3, No.5, 1996, p.605-28
PUNCTURE PROTECTION OF GEOMEMBRANES. I. THEORY
Wilson-Fahmy R F; Narejo D; Koerner R M
Parsons Brinckerhoff; Carleton,University; Drexel,University

A theoretical analysis which examines the puncture behaviour of geomembranes is presented. The method of analysis is applied to unprotected geomembranes as well as geomembranes protected using relatively thick non-woven geotextiles. The puncturing object is characterised by its shape and height above a firm subgrade. The geomembrane behaviour is considered in terms of its tensile load-extension behaviour and the protection material is characterised by both its thickness and its load-extension behaviour. A parametric study is presented to highlight the relative importance of the various factors affecting geomembrane puncture. 6 refs.

USA
Accession no.622410

**Item 142**
Geosynthetics International
3, No.5, 1996, p.565-82
AN INTERFACE PULL-OUT FORMULA FOR EXTENSIBLE SHEET REINFORCEMENT
Sobhi S; Wu J T H
Colorado, Department of Transportation; Colorado, University

An analytical model is presented for predicting and interpreting pull-out test results, used to evaluate soil-reinforcement interface properties, in a unified and consistent manner. The model is based on three postulates that were deduced from the measured behaviour of laboratory pull-out tests and numerical results from finite element analyses. A number of applications of the interface pull-out formula for predicting and interpreting the results of pull-out tests are presented, including prediction of the active length at a given applied pull-out force, prediction of the pull-out failure force for reinforcement of a given length, determination of the coefficient of friction from results of a pull-out test, and prediction of the displacement at any point along the reinforcement for a given applied pull-out force. Results using the interface pull-out formula are shown to be in good agreement with the results of an instrumented pull-out test and finite element analyses. 23 refs.
USA
Accession no. 622409

Item 143
Geosynthetics International
3, No.4, 1996, p.537-49
FULL SCALE HIGHWAY LOAD TEST OF FLEXIBLE PAVEMENT SYSTEMS WITH GEORGRID REINFORCED BASE COURSES
Collin J G; Kinney T C; Fu X
Collin Group Ltd.; Alaska, University at Fairbanks

The results are discussed of tests carried out on the use of geosynthetics to improve the performance of flexible road surfaces. A full scale test research program was carried out using a 20 kN moving wheel load to determine the benefit of using a stiff biaxial geogrid between the base and the subgrade of a flexible road surface system, with the traffic benefit ratio (TBR) defined as the ratio of the number of load cycles of a stiff geogrid reinforced section to the number of load cycles of an unreinforced section for a given level of performance. 16 refs.
USA
Accession no. 614803

Item 144
Geosynthetics International
3, No.4, 1996, p.517-36
GEOMEMBRANE RESPONSE IN THE WIDE STRIP TENSION TEST
Merry S M; Bray J D
Utah, University; California, University

The results are discussed of strain controlled, uniaxial tension tests performed on a PVC and an HDPE membrane, from which the stress-strain response of the geomembrane can be calculated. Measurements were taken at specific locations on the geomembrane specimen, which combined with results from photographic analyses, allowed the specimen width and thickness to be determined during the tests. 12 refs.
USA
Accession no. 614802

Item 145
Geosynthetics International
3, No.4, 1996, p.493-515
RESPONSE OF A WOVEN AND A NON-WOVEN GEOTEXTILE TO MONOTONIC AND CYCLIC SIMPLE TENSION
Ashmawy A K; Bourdeau P L
Edited by: Georgia, Institute of Technology; Purdue, University

Tension tests were performed to investigate the load-elongation behaviour of two geotextiles, a woven polyester and a non-woven polypropylene, under monotonic and cyclic loading conditions. Creep tests under constant load were also performed in order to examine the time-dependent properties of both textiles. A wide difference in behaviour was observed between the geotextiles due to different structures, manufacturing processes and polymer types. Visual inspection showed that progressive breakage of bonds between the fibres, and reorientation of the fibres were the main mechanisms controlling failure of the nonwoven geotextile, and that the behaviour of the woven geotextile was mainly affected by polymer characteristics and exhibited nearly linear behaviour under monotonic and cyclic load to the number of load cycles. The model obtained can be used to predict the permanent deformation as a function of the cyclic loading level and number of load cycles, or to establish fatigue criteria for design. 19 refs.
USA
Accession no. 614801

Item 146
European Chemical News
DUPONT TO RELEASE NEW BIODEGRADABLE PLASTIC
It is briefly reported that DuPont has launched its biodegradable plastic, DuPont Biomax. The polymer is a modified form of PETP, which has shorter chain lengths to enhance biodegradability. The properties of the plastic can be tailored to mimic polyester or PP. DuPont Biomax can be made into fibres, films and resins. Applications include geotextiles, agricultural films and plant pots, single-use waste bags and domestic wipes, and disposable nappies, plates and cups.
DUPONT CO.
USA
Accession no. 614679

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Item 147

**Fibres & Textiles in Eastern Europe**

**STUDIES OF RAW MATERIALS AGEING IN ARTIFICIAL CLIMATIC CONDITIONS FOR GEOFABRICS PRODUCTION**
Chodynski A; Jachniak A; Rygiel M
Beskidian Textile Institute

A description is given of the wearing process of synthetic fibres following sunlight absorption. Resistance to UV rays using the Xenotest test apparatus was evaluated for strips of polypropylene foil and polyester fibre. The decrease in strength was determined with reference to the impact of radiation on the strips and fibres which are designed for use in geotextile applications. 9 refs.

EASTERN EUROPE; POLAND
Accession no.612395

Item 148

**Rubber and Plastics News**
26, No.5, 7th Oct.1996, p.27

**2 GROUPS LOOKING TO COMBAT TYRE PILES**
Sisson J

With the number of scrap tyres in California’s stockpiles in the millions, two groups are looking for alternatives to combat the problem. GeoSyntec Consultants was awarded a two-year contract by the California Integrated Waste Management Board to investigate several civil engineering uses for waste tyres. The IWMB contract, awarded to the environmental firm in July, grants 245,000 US dollars for the proposed projects. With the board still preparing the final scope of contract, GeoSyntec expects to receive its first project in October 1996. The Boca Raton, Florida-based company is anticipating great success with the contract and is optimistic about its impact on the future of waste tyres.

GEOSYNTEC CONSULTANTS; CALIFORNIA INTEGRATED WASTE MANAGEMENT BOARD
USA
Accession no.608022

Item 149

**Plastics Technology**

**NEW APPLICATIONS BREED MORE WAYS TO PROCESS TPOS**
Sherman L M

A review is presented of new applications for thermoplastic polyolefins and the new processing methods used for their manufacture. Having established themselves in the injection moulded automotive application sector, film and sheet extrusion and thermoforming now appear to be the primary new processing opportunities for TPOs, as well as some calendering, it is reported. Applications considered with reference to actual developments include geotextiles, pond and landfill linings, roofing membranes, heavy gauge industrial packaging, wire and cable insulation extrusion and jacketing, the use of two-shot low pressure injection moulding, and bottle blow moulding and rotomoulding.

USA
Accession no.608021

Item 150

**Geosynthetics International**
3, No.1, 1996, p.145-54

**DISCUSSION OF ‘HDPE GEOSYNTHETICS: PREMATURE FAILURES AND THEIR PREDICTION’**
Bright D G; Peggs I D; Kanninen M F
Tensar Corp.

A discussion by Bright of the above paper by Peggs and Kanninen (ibid, 2, No.1, 1995, p.327-39) is presented. The intent of the authors of the paper and the purpose of extrapolating the phenomenon of stress cracking, which occurs in plastic pipe and geomembranes, to geogrids are questioned. A response by Peggs and Kanninen is included. 18 refs.

USA
Accession no.610081

Item 151

**Geosynthetics International**
3, No.1, 1996, p.107-24

**PERFORMANCE TEST FOR ASSESSMENT OF LONG-TERM CREEP BEHAVIOUR OF SOIL-GEO SYNTHETIC COMPOSITES**
Wu J T H; Helwany S M B
Colorado,University; Texas,University

A simple laboratory performance test was devised for the assessment of long-term creep behaviour of geosynthetic reinforcement resulting from soil/geosynthetic interaction. In the test, the geosynthetic reinforcement and the confining soil deformed in an interactive manner under a sustained surcharge that was applied to the soil over a long period of time. Two long-term performance tests were conducted with different confining soils, a clean sand and a kaolin clay. The tests clearly indicated that the long-term creep deformation of the geotextile reinforcement was significantly affected by the time-dependent deformation characteristics of the confining soils. It could be misleading to evaluate the long-term creep potential of a soil-geosynthetic composite based solely on the results of geosynthetic element creep test such as constant load strip tensile tests and confined creep tests which did not account for time-dependent deformation of the confining soil. 13 refs.

USA
Accession no.610081
References and Abstracts

Item 152
Geosynthetics International
3, No.1, 1996, p.85-105
GEOTEXTILE CHARACTERISATION AND PORE-SIZE DISTRIBUTION. I. A REVIEW OF MANUFACTURING PROCESSES
Bhatia S K; Smith J L
Syracuse,University

A review of the literature on the manufacturing processes for geotextiles is presented. Geotextile types are described, including polymer types, fibre types, woven geotextiles and non-woven geotextiles (prepared by mechanical bonding, thermal bonding and chemical bonding). The testing of geotextiles is discussed. Pore size distribution of woven geotextiles, non-woven geotextiles, heat-bonded geotextiles and mechanically-bonded geotextiles is considered. 31 refs.
USA
Accession no.608020

Item 153
Geosynthetics International
WALLS REINFORCED WITH FIBRE-REINFORCED PLASTIC GEOGRIDS IN JAPAN
Miyata K
Shimizu Corp.

Geosynthetic reinforced soil(GRS) retaining walls reinforced with high TS and stiffness fibre-reinforced plastic (glass fibre/vinyl ester resin) geogrids are described. The geogrid properties are discussed and full-scale field tests using three different wall facings are presented. The performance of the test walls is compared with the results of finite element method analyses which were used to simulate the construction and loading of the field tests. The analyses indicate that geosynthetic stiffness affects wall face deformation. A case history which describes the construction of a GRS retaining wall is also presented. 3 refs.
JAPAN
Accession no.608019

Item 154
Official Journal of the E.C.: L Series
LEGISLATION

This comprehensive report supplies details of a Commission decision, taken on the 24th June 1996, on the procedure for attesting the conformity of construction products pursuant to Article 20 (2) of Council Directive 89/106/EEC as regards geotextiles. The article covers their use as fluid or gas barriers, for drainage and filtration, for reinforcement and as protective layers.
EUROPEAN COMMUNITY; EUROPEAN UNION; WESTERN EUROPE-GENERAL
Accession no.607468

Item 155
Geosynthetics International
COMBINED ALLOWABLE STRENGTH REDUCTION FACTOR FOR GEOSYNTHETIC CREEP AND INSTALLATION DAMAGE
Allen T M; Bathurst R J
Washington,State Department of Transportation; Ontario,Royal Military College of Canada

The effect of synergism on the combined effect of polymeric creep and installation damage is discussed by examining creep data for undamaged and installation-damaged geosynthetic specimens. A methodology was developed that uses data from both creep tests and index tests to reconstruct installation-damaged isochronous creep curves. 35 refs.
CANADA; USA
Accession no.606937

Item 156
Geosynthetics International
METHOD FOR MEASURING GEOMEMBRANE SURFACE ROUGHNESS
Dove J E; Frost J D
Georgia,Institute of Technology

A method is described for quantitatively measuring the roughness of geomembrane surfaces. This method uses stereology concepts together with optical profilometry techniques to determine the surface roughness parameter. A surface roughness classification is proposed which defines four categories of geomembrane texturing. 10 refs.
USA
Accession no.606936

Item 157
Geosynthetics International
NEW UNIT-CELL TO STUDY THE DEFORMATION MECHANISM OF SUPER SOFT CLAY OVERLAID BY GEOGRID AND SAND
Fakher A; Jones C J F P
Newcastle,University

A new form of the shear box unit-cell test for use on super soft clay is presented. Each test specimen consisted of sand, one of three types of geogrid reinforcement, and super soft clay. 28 refs.
EUROPEAN COMMUNITY; EUROPEAN UNION; UK; WESTERN EUROPE
Accession no.606935

Item 158
Geosynthetics International
3, No.3, 1996, p.329-47
COMPARISONS OF PREDICTED AND
OBSERVED FAILURE MECHANISMS IN MODEL REINFORCED SOIL WALLS
Palmeira E M; Gomes R C
Brasilia, University; Ouro Preto, Federal University
Comparisons of predicted stability analyses to measured and observed results of model reinforced soil walls are presented using theoretical design methods. The model walls were failed under a footing surcharge at different locations on the fill surface. These surcharges were compared to results that were predicted using the rigid wall approach for the reinforced soil mass, plane and circular failure surfaces and the two-wedge failure mechanism analyses. 15 refs.
BRAZIL
Accession no. 606934

Item 159
Geosynthetics International
3, No. 3, 1996, p. 301-28

GEOTEXTILE CHARACTERISATION AND PORE-SIZE DISTRIBUTION. III. COMPARISON OF METHODS AND APPLICATION TO DESIGN
Bhatia S K; Smith J L; Christopher B R
Syracuse, University
Performance characteristics of six different test methods for evaluating pore size distribution of geotextiles are discussed. Twenty eight geotextiles were evaluated by dry sieving, hydrodynamic sieving, wet sieving, bubble point method, mercury intrusion porosimetry and image analysis. 21 refs.
USA
Accession no. 606933

Item 160
Geosynthetics International
3, No. 2, 1996, p. 277-96

OUT-OF-PLANE TENSILE BEHAVIOUR OF GEOSYNTHETIC CLAY LINERS
Koerner R M; Koerner G R; Eberle M A
Drexel, University
The out-of-plane tensile behaviour was studied for various geosynthetic clay liners (GCLs), manufactured using a variety of woven and non-woven geotextiles and textured and smooth HDPE geomembranes, in combination with various forms of bentonite, i.e. powdered and granular. The tensile response curves indicated that GCL strength was largely dependent on the carrier material types from which the GCL was manufactured. Fibre reinforcement effects as well as orientation effects were relatively small for this type of test. The effects of hydration and seams were also assessed. The results showed that GCLs could withstand considerably greater out-of-plane deformation than compacted clay liners. 9 refs.
USA
Accession no. 605751

Item 163
Geosynthetics International
INFLUENCE OF STRAIN RATE, SPECIMEN LENGTH AND CONFINEMENT ON MEASURED GEOTEXTILE PROPERTIES
Boyle S R; Gallagher M; Holtz R D
Norwegian Geotechnical Institute; Washington, University
In-isolation and in-soil tests were performed on four woven (three PP slit-film geometries and one polyester
multifilament) and two non-woven geotextiles (both PP
needle-punched) in order to investigate the effect of strain
rate, specimen length and confinement in soil on the
measured strength characteristics. It was shown that
woven geotextiles were affected by strain rate but not by
confinement. Non-woven geotextiles were influenced by
both confinement and specimen gauge length. It was
concluded that different manufacturing techniques
influenced measured strength properties and that a
standardised wide-width strip tensile test, such as ASTM
D 4595, might not be an appropriate method for all types
of geosynthetic reinforcement products. 27 refs.

NORWAY; SCANDINAVIA; USA; WESTERN EUROPE

Accession no.605750

Item 164

Geosynthetics International
3, No.2, 1996, p.181-203

STRAIN-SOFTENING BEHAVIOUR OF WASTE
CONTAINMENT SYSTEM INTERFACES
Gilbert R B; Byrne R J
Texas, University; Golder Associates Inc.

The causes and design implications of strain-softening
behaviour for geosynthetic containment system interfaces
are discussed. Mechanisms that contribute to strain-
softening include clay particle reorientation, geosynthetic
polishing and geosynthetic failure. Laboratory test results
are summarised for typical containment system interfaces
that exhibit strain-softening behaviour. Design
implications of strain-softening behaviour are then
investigated using a one-dimensional analytical model and
a two-dimensional numerical model. 29 refs.

USA

Accession no.605749

Item 165

Geosynthetics International
3, No.2, 1996, p.155-80

GEOTEXTILE CHARACTERISATION AND
PORE-SIZE DISTRIBUTION. II. A REVIEW OF
TEST METHODS AND RESULTS
Bhatia S K; Smith J L
Syracuse, University; O’Brien & Gere Engineers

Six methods commonly used for evaluating the pore-size
distribution of geotextiles in the U.S. and Europe are
reviewed, i.e. dry sieving, hydrodynamic sieving, wet
sieving, bubble point method, mercury intrusion
porosimetry and image analysis. Results obtained for
evaluation of pore-size distribution characteristics of over
580 specimens from 28 different geotextiles are presented
and discussed. 25 refs.

EUROPE-GENERAL; USA

Accession no.605748

Item 166

Geosynthetics International
2, No.6, 1995, p.1099-113

EVALUATION OF PVC GEOMEMBRANE
SHRINKAGE DUE TO PLASTICISER LOSS
Giroud J P
GeoSyntec Consultants

When a plasticiser migrates out of a PVC geomembrane,
the geomembrane shrinks. This paper presents equations
that give the changes in volume and dimensions of the
geomembrane as a function of the plasticiser content
before and after shrinkage. A second series of equations
is presented, which gives the changes in volume and
dimensions of the geomembrane as a function of the
plasticiser loss ratio. These equations depend on the
densities of constituents of the geomembrane.
Approximate equations that do not depend on those
densities are, however, presented. 3 refs.

USA

Accession no.605747

Item 167

Geosynthetics International
2, No.6, 1995, p.1049-97

ANALYSIS OF STRAIN CONCENTRATION
NEXT TO GEOMEMBRANE SEAMS
Giroud J P; Tisseau B; Soderman K L; Beech J F
GeoSyntec Consultants

A theoretical analysis of the above shows that the
maximum strain concentration occurs next to the seams
when geomembranes are subjected to tensile strain,
regardless of the causes of the tensile strain. Calculations
performed for typical seams show that the stain in the
geomembrane next to a seam can be more than twice as
large as the average tensile strain in the geomembrane.
A geomembrane embrittled by low temp., or for other
reasons, may not be able to withstand such a strain. A
parametric study indicates the influence of strain type and
geometry on the magnitude of strain. A comparison
of the seams typically used for PE geomembranes indicates
that fusion seams tend to cause fewer strain concentrations
than extrusion seams. 6 refs.

USA

Accession no.605746

Item 168

Geosynthetics International
2, No.6, 1995, p.1019-48

THEORETICAL ANALYSIS OF
GEOMEMBRANE PUNCTURE
Giroud J P; Badu-Tweneboah K; Soderman K L
GeoSyntec Consultants

A theoretical analysis of the mechanism of geomembrane
puncture, based on a simple model, is presented. The
analysis shows that the geomembrane puncture resistance
depends on the diameter of the contact area between the geomembrane and the puncturing object, the thickness of the geomembrane and the tensile properties of the geomembrane. An equation is established for expression of the geomembrane puncture resistance measured in a probe test as a function of the geomembrane characteristics and the diameter of the probe. The predictions made are shown to be consistent with the limited amount of data in the literature. The analysis is then used to establish a relationship between a geomembrane resistance to puncture measured in a laboratory probe test and the resistance to puncture of a geomembrane subjected to pressure applied by a liquid while resting on a layer of stones of approximately uniform size and shape. 4 refs.

USA
Accession no.605743

Item 171
Geosynthetics International
2, No.6, 1995, p.897-952
UPLIFT OF GEOMEMBRANES BY WIND
Giroud J P; Pelte T; Bathurst R J
GeoSyntec Consultants; Canada, Royal Military College

Experimental data on uplift of geomembranes by wind are summarised and a method is presented for determining the maximum wind velocity that an exposed geomembrane can withstand without being uplifted, the required thickness of a protective layer placed on the geomembrane that would prevent it from being uplifted, the tension and strain induced in the geomembrane to verify that they are below the allowable tension and strain of the geomembrane, and the geometry of the uplifted geomembrane. Practical recommendations are made to prevent the wind from uplifting geomembranes or to minimise the magnitude of geomembrane uplift by the wind. 12 refs.

Canada; USA
Accession no.605742

Item 172
Geotextiles and Geomembranes
14, Nos.5/6, June/July 1996, p.313-25
REMEDIATION OF EXISTING CANAL LININGS
Comer A; Kube M; Sayer K
US, Bureau of Reclamation

Results are reported of the monitoring of a soil-covered PP geomembrane in South Dakota, an exposed HDPE geomembrane in Kansas and an exposed ultra-low density PE geomembrane in Nebraska. The results indicate that the geomembranes used as canal liners reduce seepage in the canals when they are constructed in highly permeable or collapsible types of soils. 8 refs.

USA
Accession no.604985

Item 173
Geotextiles and Geomembranes
14, Nos.5/6, June/July 1996, p.301-11
GEOTEXTILES USED AS FLEXIBLE FOAMS
Koerner R M; Koerner G R
Drexel, University

The use of geotextiles as flexible forming systems is discussed and it is shown that, in contrast to other
geotextile applications, the geotextile is sacrificial in most cases, e.g. when grout or concrete is placed within the geotextile form. Five different infrastructure-related applications are considered, i.e. mine and cavern stability, geotubes and geocontainers, pile jacketing, erosion control mattresses, and underpinning to reconstitute bearing capacity. Design considerations are mentioned. 9 refs.

USA
Accession no.604984

Item 174
Geotextiles and Geomembranes
14, Nos.5/6, June/July 1996, p.265-75
THREE-DIMENSIONAL WOVEN GEOTEXTILES FOR CONTAINMENT DIKE CONSTRUCTION
Austin D N; Theisen M S
Synthetic Industries Inc.

A report is presented on the background, selection, installation and performance of the three-dimensional woven geotextile (Pyramat, a PP-based material from Synthetic Industries) used for erosion protection along 122 m of levee on a demonstration project on the Houston Ship Channel in Galveston Bay, Texas. Chronological data, field observations and photographs are included to complement the observations and conclusions reached by the authors and others, from the time of installation to the present. 13 refs.

USA
Accession no.604983

Item 175
Geotextiles and Geomembranes
14, Nos.5/6, June/July 1996, p.253-64
GEOMEMBRANE APPLICATION FOR A ROLLER COMPACTED CONCRETE(RCC) DAM
Whitfield B L
ATEC Associates Inc.

Specific design details and construction activities related to the installation of a PVC geomembrane for a RCC dam are presented, particular attention being paid to pre-casting challenges, panel placement challenges, geomembrane welding challenges, and maintenance of installed geomembrane materials.

USA
Accession no.604982

Item 176
Geotextiles and Geomembranes
14, Nos.7/8, July/Aug.1996, p.377-91
GEOTEXTILE REINFORCEMENT OF SOFT LANDFILL PROCESS SLUDGE TO FACILITATE FINAL CLOSURE: AN INSTRUMENTED CASE STUDY
Guglielmetti J L; Koerner G R; Battino F S
DuPont de Nemours E.I.,& Co.Inc.

Results are presented of an instrumented, geotextile reinforced landfill cap for a process sludge landfill. The geotextile was instrumented with foil strain gauges and the sewn seams instrumented with extensometers. A critique of the analysis of the installation practice as well as the effectiveness of the geotextile is mentioned. 2 refs.

USA
Accession no.603791

Item 177
Geotextiles and Geomembranes
14, Nos.7/8, July/Aug.1996, p.393-408
ADVANCES IN HDPE BARRIER WALLS
Thomas R W; Koerner R M
TRI/Environmental Inc.

Details are given of the installation techniques, applications and properties of HDPE barrier walls for landfill sites. Emphasis is given to diffusive transport through HDPE. 13 refs.

USA
Accession no.603792

Item 178
Geotextiles and Geomembranes
14, Nos.7/8, July/Aug.1996, p.365-76
REQUIREMENTS AND TESTING OF PROTECTIVE LAYER SYSTEMS FOR GEOMEMBRANES
Seeger S; Muller W
Germany,Federal Institute for Materials Research & Testing

An overview is presented of existing types of protective layer systems for geomembranes. The requirements and selected results of related research programmes are discussed. 11 refs.

EUROPEAN COMMUNITY; EUROPEAN UNION; GERMANY; WESTERN EUROPE
Accession no.603790
Item 180
Geotextiles and Geomembranes
14, Nos.7/8, July/Aug.1996, p.341-64
USE OF GEOSYNTHETICS IN PIGGYBACK LANDFILLS: A CASE STUDY
Stulgis R P; Soydemir C; Telgener R J; Hewitt R D
Haley & Aldrich Inc.
A case study is presented to demonstrate how geosynthetic materials were used to address settlement and stability problems in a piggyback landfill design for a sludge monofil. 11 refs.
USA
Accession no.603789

Item 181
Geotextiles and Geomembranes
14, Nos.7/8, July/Aug.1996, p.331-9
OVERVIEW OF CORPS OF ENGINEERS WASTE CONTAINMENT ACTIVITIES INVOLVING GEOSYNTHETICS
Jaros D L
US Army Corps of Engineers
Details are given of the US Army Corps of Engineers involvement in various environmental restoration programmes which use geosynthetics and the activities being conducted to further advance geosynthetic engineering. Geosynthetic guidance development, design and construction issues, and training are discussed along with examples of geosynthetic containment applications.
USA
Accession no.603788

Item 182
Journal of Plastic Film & Sheeting
12, No.2, April 1996, p.149-56
THERMOPLASTIC ELASTOMERIC POLYOLEFINS(TPO) IN FILM APPLICATIONS
Shannon Z
Quantum Chemical Co.
The performance of the Flexathane TPO TP1300-HC and the developmental TPO “A” in blown and cast films is discussed. The data show that the resins offer a good balance of physical properties, such as high heat resistance, superior impact strength and high resistance to puncture. Other applications are considered, including medical materials, geomembrane liners for landfills, and automotive applications. 3 refs.
USA
Accession no.600885

Item 183
Geotextiles and Geomembranes
14, Nos.3/4, March/April 1996, p.223-37
GEOSYNTHETIC USE IN TRENCHLESS PIPE

REMEDIATION AND REHABILITATION
Koerner G R; Koerner R M
Drexel University
The currently used trenchless techniques for pipe remediation and rehabilitation are described and their respective advantages and disadvantages considered. Typical costs and other details are also presented. Particular attention is paid to those systems which use geosynthetics or other polymeric materials. The main application area is currently underground sewer pipelines, but the material presented can be applied to other underground pipeline and tunnel situations. 7 refs.
USA
Accession no.599428

Item 184
Geotextiles and Geomembranes
14, Nos.3/4, March/April 1996, p.207-21
EVALUATION AND STANDARDISATION OF ROLLED EROSION CONTROL PRODUCTS
Allen S R
TRI/Environmental Inc.
The history of advancements in rolled erosion control technology is outlined. A summary is presented of the efforts currently underway by the Erosion Control Technology Council to establish erosion control industry standards for terminology, index tests and performance criteria. Erosion control products discussed include geosynthetic nettings, geotextiles and PP blankets. Testing of thickness, resiliency, mass per unit area, water absorption, flexibility, swelling, light penetration, smoulder resistance, density and tensile properties is considered. 4 refs.
USA
Accession no.599427

Item 185
Geotextiles and Geomembranes
14, Nos.3/4, March/April 1996, p.201-5
GEOSYNTHETIC CONTAINMENT BENEATH STOCKHOLM-ARLANDA AIRPORT
Bystrom J; Overmann L K; Ericsson L O
Golder Associates AB; Golder Construction Services; Swedish Civil Aviation Administration
The construction of a third runway at the above airport is discussed with particular reference to the lining system designed to protect the water resource under the runway from deicing products and solvents used to remove rubber deposits from the runway. The system involves use of a geosynthetic clay liner beneath the geomembrane (HDPE) to form a composite liner and/or a geotextile above the geomembrane as a protective cushion.
SCANDINAVIA; SWEDEN; USA; WESTERN EUROPE
Accession no.599426
Item 186
**Geotextiles and Geomembranes**
14, Nos.3/4, March/April 1996, p.175-86

**ENHANCED PERFORMANCE OF ASPHALT PAVEMENTS USING GEOCOMPOSITES**
Austin R A; Gilchrist A J T
Netlon Ltd.

A report is presented on the development and testing of a composite combining a stiff PP geogrid with a geotextile, thus producing a material with the handling and installation benefits of a geotextile, combined with the performance advantages of a stiff geogrid. A case study detailing the use of the composite reinforcement is also presented. 4 refs.

EUROPEAN COMMUNITY; EUROPEAN UNION; UK; WESTERN EUROPE
Accession no.592925

Item 187
**Plasticulture**
No.106, 1995, p.40-6

**PRODUCTION NURSERY AND LANDSCAPE MANAGEMENT USES FOR GEOTEXTILES**
Appleton B L
Virginia, Tech University

Applications of geotextiles in nurseries for tree and shrub cultivation and in landscape management are described. These include containers for tree and shrub growth, trench linings, bed coverings, sleeves for holding nursery stock, collars serving as barriers to weed growth and as carriers for fertilisers and herbicides, covers for providing protection in winter and shade in summer, guying systems for tree staking, protective wrappings for tree trunks, and systems for root redirection and soil aeration. 8 refs.

ACF ENVIRONMENTAL; DALEN PRODUCTS INC.; REEMAY INC.; DEWITT & CO.INC.
USA
Accession no.598426

Item 188
**Plastics News(USA)**
8, No.11, 13th May 1996, p.3

**GUNDLE/SLT ADDS PRODUCT LINE WITH SGS GEOSYSTEMS DEAL**
King R

The acquisition of British geomembrane manufacturer SGS Geosystems Ltd. by Gundle/SLT Environmental Inc. is briefly discussed. The acquisition will add blown film geomembrane to Gundle/SLT’s list of extruded products made outside the US. The purchase of SGS gives Gundle/SLT a combined capacity of 250 million pounds in the impermeable geomembrane market, or around half the world share, it is reported.

GUNDLE/SLT ENVIRONMENTAL INC.; SGS GEOSYSTEMS LTD.
EUROPEAN COMMUNITY; EUROPEAN UNION; UK; USA; WESTERN EUROPE
Accession no.591197
Item 191

Shell Chemicals Europe Magazine
No.4, Nov.1995, p.9-12

FOAM FOUNDATIONS WHY ON EARTH NOT?
Baker A
Shell Chemicals Europe

Expanded polystyrene foam as a civil engineering material is discussed with reference to its use as a geofoam for solving geotechnical problems. Uses include a lightweight fill under the sub-grade of a road, built over a low load-bearing soil; in soil drainage; vibration damping, as a stress release material where ground movement occurs; for gas venting; and soil stabilisation.

EUROPE-GENERAL
Accession no.590998

Item 192

Plastics World
54, No.5, May 1996, p.55-6

POLYUREAS ARE BOOMING IN CONSTRUCTION MARKETS
Smock D

Jeffamine-based polyurea materials are replacing standard PUR and other thermoset materials in applications ranging from transportation body panels to construction-site coatings. Due to fast reactivity and cure, these systems are virtually unaffected by moisture when applied, a tremendous factor in their rapid growth in construction-related work. Gusmer Machinery Equipment says equipment for polyureas now accounts for about one-third of its spray equipment sales. Specialty Products will be selling systems for spray coating polyureas on BP pipe in permafrost applications. One of the fastest growing applications for the polyurea spray elastomers is replacement of thermlastic sheet for geomembranes, such as pond liners.

TEXACO CHEMICAL CO.
USA
Accession no.589664

Item 193

Plast 21
No.40, Jan./Feb.1995, p.16-9

Spanish

FROM GEOTEXTILES TO LARGE TEXTILE COVERINGS
Monjo J

Applications of fabrics and polymer coated fabrics as geotextiles and structural materials are described. Data are presented for the costs and properties of the most commonly used materials.

EUROPEAN COMMUNITY; EUROPEAN UNION; SPAIN; WESTERN EUROPE
Accession no.588883

Item 194


STUDY OF THE BONDING BETWEEN FABRIC AND BITUMEN EMULSION IN A STRESS ABSORBING MEMBRANE INTERLAYER
Woodside A R; McIlhagger R; Woodward W D H; Clements H W
Ulster, University (Institute of Materials)

Mechanical pull-off tests and water absorption and retention measurements were performed on PP, glass, cotton and jute fabrics to assess their bonding with bitumen emulsion in stress absorbing membrane interlayers for use in road construction. The fabric structure and the depth of emulsion tack coat were the variables which most affected the adhesive bond strength. The temperature of tack coat application had no effect. All the fabrics absorbed and retained water to a certain extent, which was considered to affect the bonding process. Samples consisting of fabrics sandwiched between asphalt cores were sheared by a direct shear mechanism and by a short beam shear test, and the results were compared. Emulsion tack coat rate and fabric type and structure had a considerable effect on shear strength, while fabric orientation had no effect. 6 refs.

EUROPEAN COMMUNITY; EUROPEAN UNION; NORTHERN IRELAND; UK; WESTERN EUROPE
Accession no.586739

Item 195

Waste News
1, No.23, 5th Feb.1996, p.15

I-CORP UNVEILS LANDFILL LEAK FINDER

I-Corp International is making available a European computer-enhanced electrical method for locating leaks in plastic liners under soil layers. The system can be used to detect damage to geomembranes caused by drainage stones in landfills or on heap leach pads. Recycling machinery available from other US companies include a bale processing system, a debagger, compactors, vertical balers and lifting gear for hydraulic refuse containers on rear-loading packers. Fibrex has designed a drum cover made of recycled HDPE and Biotech has developed degradable starch-based resins for compostable bags.

I-CORP INTERNATIONAL INC.; HAAHJEM NORTH AMERICA INC.; FIBREX RECYCLING CONTAINERS; MORBARK SALES CORP.; BIOTECH; KOMAR INDUSTRIES INC.; QWIK-TIP INC.
USA
Accession no.584467
References and Abstracts

Item 196
Construction & Building Materials
9, No.6, 1995, p.403-11
DESIGN AND CONSTRUCTION OF EXPANDED PS EMBANKMENTS. PRACTICAL DESIGN METHODS AS USED IN THE UK
Thompsett D J; Walker A; Radley R J; Grieveson B M
Vencel Resil Ltd.; Surrey, University
A brief history is given of the use of expanded PS in lightweight fill for road embankments. UK design requirements and physical properties of the PS foam are discussed together with two case studies. 17 refs.
EUROPEAN COMMUNITY; EUROPEAN UNION; UK; WESTERN EUROPE
Accession no.582032

Item 197
Construction & Building Materials
9, No.6, 1995, p.389-401
ORIENTED POLYMER GRID REINFORCEMENT
Carter G R; Dixon J H
Netlon Ltd.
A review is given of the use of high strength oriented HDPE or PP grids for various civil engineering applications. The major areas of use mentioned include reinforced soil walls and slopes, reinstatement of slope failure, embankment foundations over soft soil, reinforcement of road bases for paved roads, and asphalt reinforcement. 41 refs.
EUROPEAN COMMUNITY; EUROPEAN UNION; UK; WESTERN EUROPE
Accession no.581529

Item 198
High Performance Textiles
Feb.1996, p.5-6
CONSTRUCTION INDUSTRIES TO BE TARGETED BY NONWOVENS SECTOR
The European Disposables and Nonwovens Association (EDANA) is forecasting a major thrust by international nonwoven companies towards developing applications in the construction industries. Nonwovens are now the most widely used base material in high performance, bitumen-treated waterproof roofing sheeting. Thermal and acoustic insulation are provided by a range of different bulky nonwovens. If a flat roof is to provide a roof garden, for example, then a waterproof nonwoven layer can provide a filter and a drainage layer. When used as a protective interlayer during casting of concrete floors on poor subsoil, a layer of nonwoven will prevent any mingling of the subsoil and the new concrete.
EDANA
BELGIUM; EUROPEAN COMMUNITY; EUROPEAN UNION; WESTERN EUROPE
Accession no.581626

Item 199
British Plastics and Rubber
Feb.1996, p.22
TESTING FOR DAMAGE FROM BURIED STONES
It is briefly reported that the long term performance of geotextiles and geomembranes is closely allied to degradation from chemical and biological influences, but the principal cause of degradation appears to be stones. ERA Technology has adapted a French test in which the geosynthetic is placed in a bed of standard alumina grit and compressed under a dynamic load. The material is examined optically and tested for tensile strength. For geomembranes, a soft metal layer is inserted to record the degree of indentation caused by a standard fill.
ERA TECHNOLOGY LTD.
EUROPEAN COMMUNITY; EUROPEAN UNION; UK; WESTERN EUROPE
Accession no.581109

Item 200
Journal of Vinyl and Additive Technology
1, No.4, Dec.1995, p.230-2
LEAD STABILISERS AND ALTERNATIVES IN WIRE AND CABLE AND GEOMEMBRANES
Baker P; Grossman R F
Cookson Specialty Additives
Lead replacement heat stabilisers have made considerable inroads in areas where water resistance is not significant, primarily in wire jackets and insulations not for wet locations. In areas where short-term moisture resistance is required, such as with flexible cord insulation and electrical tapes., non-lead products are either in use or under development. In those areas where long-term water resistance is required, as with geomembranes and many wire insulations, despite much experimentation, commercial products are not yet in use as yet in the United States. The factors involved are discussed. 3 refs.
USA
Accession no.575108
SUCCESSFUL GEOMEMBRANE PRODUCTION
Coulson J
SGS Geosystems

The use and production of geomembranes is discussed, with particular reference to the operation at SGS Geosystems. The choice of material is considered, specific properties necessary for the optimum performance of the membrane, and the extrusion process at SGS Geosystems is described, including methods of thickness control.

EUROPEAN COMMUNITY; EUROPEAN UNION; UK; WESTERN EUROPE
Accession no.572733

EXTRUDED MEMBRANES

Flat die extrusion lines are manufactured by Amut for the production of geomembranes for geotechnical engineering applications. Brief details are given of the lines.

AMUT SPA
EUROPEAN COMMUNITY; EUROPEAN UNION; ITALY; WESTERN EUROPE
Accession no.571187

MARKETING NOTES

Brief details are given of some data published concerning the market for plastic film and sheet particularly for packaging, geomembranes, and greenhouses.

USA
Accession no.569394

LEAD STABILISERS AND ALTERNATIVES IN WIRE AND CABLE AND GEOMEMBRANES

Baker P; Grossman R F
Cookson Specialty Additives
(SPE, Palisades Section; SPE, Polymer Modifiers & Additives Div.)

There are two distinct reasons for the widespread use of lead stabilisers in compounds based on halogenated polymers designed for wire insulation or geomembrane: very good performance/cost characteristics and unusually good resistance to water absorption. Recent experience indicates that the favourable performance characteristics of lead stabilisers can be met by non-lead systems. Details are given. 3 refs.

USA
Accession no.563477

NON-WOVENS: GEOTECHNICAL ENGINEERING APPLICATIONS: A REVIEW
Athalye A S

A review is presented of the geotechnical civil engineering applications for which geosynthetic non wovens can be used. Included are details of applications as filters for subsurface drainage and for erosion control, their use in conjunction with inert armour units to prevent the erosion of foundations, as separation layers, in the production of both temporary and permanent road surfaces, reclamation of soft soils, reinforced soil retaining walls and embankments, and as moisture barriers, including the containment of toxic wastes. 7 refs.

INDIA
Accession no.559788

GEOFIN ROAD FIN DRAINS

British Board of Agreement; Cooper Clarke Group plc Agreement Board. Certificate 94/82

Details are given of Types 5, 6, and 10 of Geofin road fin drains for highway drainage. The products are composed of two layers of PP geotextiles separated by a core of extruded HDPE. They are designed for use in edge of pavement drains for the collection of sub-surface water. Details are given of their composition and manufacture, installation, mechanical properties, and durability.

EUROPEAN COMMUNITY; EUROPEAN UNION; UK; WESTERN EUROPE
Accession no.555781

WORLD POLYOLEFIN MARKET FORECAST

Kuhlke W C
Kuhlke & Associates
(SPE)

A survey is made of the world market for PE and PP and of technological and applicational developments influencing its future growth. Production and consumption statistics are presented. 1 ref.

USA; WORLD
Accession no.555593
FRICTION CHARACTERISTICS OF A NON-WOVEN GEOTEXTILE AND PEAT
Bouazza A; Djafer-Khodja S
Ghent,University; Algeria,Ecole Nationale Travaux
Publics
The friction characteristics, obtained from shear tests, of a non-woven geotextile and a peat soil were investigated, the geotextile being a non-woven, spun bonded polyester fabric whose continuous fibres were mechanically bonded. The study was part of an on-going research programme on low embankments constructed on reinforced, low compression soils. The results indicated that the bond friction angle of peat/reinforcement was superior to the bond friction angle of peat alone, that a good contact was achieved between non-woven geotextile and peat, that the friction coefficient decreased with normal stress, and that the contribution of adhesion should be taken into account in the design. 9 refs.
ALGERIA; BELGIUM; EUROPEAN COMMUNITY; EUROPEAN UNION; WESTERN EUROPE
Accession no.545730

Item 213
Geotextiles and Geomembranes
13, No.12, 1994, p.781-806
GEOTEXTILE STRAIN IN A FULL SCALE REINFORCED TEST EMBANKMENT
Rowe R K; Gnanendran C T
Western Ontario,University
A geotextile reinforced test embankment was constructed on a soft organic clayey silt deposit at Sackville, New Brunswick, Canada in September/October 1989. A relatively high strength polyester woven geotextile (ultimate strength 216 kN/m) was used as reinforcement. The reinforcement was instrumented with a number of electrical resistance, electromechanical and mechanical gauges. The field performance of the geotextile reinforcement during the construction of this test embankment was assessed. 7 refs.
CANADA
Accession no.545729

Item 214
Plastics Technology
41, No.3, March 1995, p.19/23
WORLD’S LARGEST SHEET LINE CUTS COSTS FOR GEOMEMBRANE MAKER
Knights M
The design and performance is described of what is described as the world’s largest sheet line. It is manufactured by HPM Corp., and installed at National Seal Co., where it is used to produce geomembranes for lining or covering landfills, ponds, reservoirs and canals. The line is able to produce sheets in high molecular weight HDPE up to 30.5 ft wide, which is twice as wide as any
sheet made at the plant previously, and in thicknesses from 0.040 to 0.120 in. Advantages of the extra wide sheets include the elimination or reduction of welds.

HPM CORP.; NATIONAL SEAL CO. USA
Accession no.544953

**Item 215**
Birmingham, c.1994, pp. 4. 12ins. 6/12/94. 42C12-62(14)-63Ag
MACMAT ANTI-EROSION GEOMAT FOR PERMANENT REVEGETATION
Maccafferri River & Sea Gabions Ltd.

Typical agricultural and civil engineering applications are described and illustrated for MacMat geomat, a geotextile product which provides effective erosion control, soil stabilisation and provides a permanent turf and vegetative root reinforcement medium. It consists of a three-dimensional mat, composed of entangled PP monofilaments that are heat bonded at the contact points. Properties are included.

EUROPEAN COMMUNITY; EUROPEAN UNION; UK; WESTERN EUROPE
Accession no.544024

**Item 216**
Journal of Plastic Film & Sheeting
10, No.3, July 1994, p.235-47
EXTENSIONAL BEHAVIOUR OF COMMON GEOMEMBRANE MATERIALS
Hoffman W A; Rhee S J; Nicholas A Union Carbide Corp.

Extensional behaviour is of major importance in selection of geomembrane materials for certain applications. Extensional behaviour is not a single attribute, but a collection, requiring a set of tests to assess the performance of each material. The results of such assessments are presented for four types of geomembrane materials (medium density PE, LLDPE, ultra-low density PE, plasticised PVC) and are used to develop a few fundamental and practical conclusions. 2 refs.

USA
Accession no.542825

**Item 217**
European Plastics News
22, No.2, Feb.1995, p.20-1
SPREADING SHEETS ACROSS THE LANDSCAPE
Coulson J
SGS Geosystems

Geomembranes are used for a variety of applications including liners for lakes, canals and reservoirs, isolating ground contamination and landfill. Research has shown that MDPE copolymer with a reference density of 0.939g/cm3 and a wide molecular weight distribution is particularly suited for use as geomembranes. When coloured black, its density becomes 0.949g/cm3. SGS Geosystems uses the radial die extrusion system to produce a blown film membrane, giving a bubble almost 2m in diameter. A gamma backscatter probe is used to monitor thickness. A recent geomembrane installation project was the encapsulation of an area of severely contaminated soil on which a chemical factory had been operating for many years. For a large landfill project, a composite lining system was used. This consisted of a primary 2mm thick MDPE geomembrane and a special needle-punched geotextile with a layer of sodium bentonite incorporated within its structure.

EUROPEAN COMMUNITY; EUROPEAN UNION; UK; WESTERN EUROPE
Accession no.540076

**Item 219**
Geotextiles and Geomembranes
13, No.10, 1994, p.657-67
STRIP FOUNDATION ON GEOGRID-REINFORCED CLAY: BEHAVIOUR UNDER CYCLIC LOADING
Das B M; Shin E C
Southern Illinois,University

Laboratory model tests to determine the permanent settlement of a surface strip foundation supported by geogrid-reinforced saturated clay and subjected to a low-frequency cyclic load are presented. In conducting the tests, the foundation was then superimposed over the static load. The variation of the maximum permanent settlement
with the intensity of the static load and the intensity of
the amplitude of the cyclic load are also presented. 9 refs.
USA
Accession no.535084

Item 220
Geotextiles and Geomembranes
13, No.9, 1994, p.591-626
CHEMICAL AGEING EFFECTS ON THE
PHYSICO-MECHANICAL PROPERTIES OF
POLYESTER AND POLYPROPYLENE
GEOTEXTILES
Mathur A; Netravali A N; O’Rourke T D
Cornell University
The influence of groundwater chemistry on the durability
of geotextiles is important for the design of municipal
and hazardous waste landfills, geotextile reinforcement
of soils and subgrades, and earth retention systems. A
series of tests are described which explore the effects of
various pH and saline environments on geotextiles, thus
contributing to an improved understanding of durability
as a basis for design. Accelerated ageing was performed
on polyester and PP geotextiles at room temperature and
temperatures elevated to 95°C for six months in saline
(pH about 8), strong alkaline (pH 10) and acidic (pH 3)
media. Property changes as a result of ageing were studied
using tensile testing, DSC, TGA and intrinsic viscosity
measurements. SEM was used to study changes in the
surface topography of the fibres on ageing. An Arrhenius
model was used to extrapolate results of this short term
study to the actual lifetime of the geotextiles. 29 refs.
USA
Accession no.529753

Item 221
Geotextiles and Geomembranes
13, No.9, 1994, p.571-90
FURTHER STUDY OF GEOMEMBRANE/
COHESIVE SOIL INTERFACE SHEAR
BEHAVIOUR
Fishman K L; Pal S
New York, University
The results presented contribute to an existing database on
the shear strength of geomembrane/cohesive soil interfaces.
Three different clay materials are studied, and the interfaces
include both smooth and textured HDPE geomembranes.
Consolidated drained and consolidated undrained direct
shear tests were performed on samples compacted wet of
optimum under both partially saturated and saturated
conditions. The effect of shear was studied through a range
from 12.7 mm/min to 0.005 mm/min. Deformations during
shear were studied and used to explain the variation in shear
strength due to the rate of shear loading for textured
geomembrane/clay interfaces. 33 refs.
USA
Accession no.531694

Item 222
Philadephia, Pa, 1993. 1/7/93. 9511T
ASTM D 5397. TEST METHOD FOR
EVALUATION OF STRESS CRACK RESISTANCE
OF POLYOLEFIN GEOMEMBRANES USING
NOTCHED CONSTANT TENSI LOAD TEST
American Society for Testing & Materials
ASTM D 5397
Details are given of the testing of polyolefin geomembrane
sheeting for stress cracking, under a constant tensile load
condition, and an accelerated environmental condition.
Photocopies and loans of this document are not available
from Rapra. It may be purchased from BSI. Please contact
Rapra for further details.
USA
Accession no.525763

Item 223
LINFLEX FIN DRAIN AND GEOTEXTILE
British Board of Agreement; B & H (Leicester) Ltd.
Agreement Board. Certificate 93/78
This certificate relates to the Linflex Fin Drain and
geomembrane for use in narrow filter drains for highway
drainage. The products are for use in edge of pavement
drains for the collection and/or disposal of sub-surface
water in accordance with the requirements of the
Department of Transport. Detail sheets are included for
Linflex types 6, 8, and 9 Fin Drains, which give
information on design and installation of the products.
Type 6 is a composite of two layers of geotextile separated
by a plastic core, and incorporating a sleeve to
accommodate the perforated or porous drainage pipe;
Linflex 8 consists of a pipe wrapped in a non-woven fabric
of heat bonded PP/PE filaments; and Linflex 9 consists
EUROPEAN COMMUNITY; EUROPEAN UNION; UK;
WESTERN EUROPE
Accession no.525770

Item 224
Plastics News International
Aug.1994, p.25/8
GROWING APPLICATION OF GEOTEXTILES
Bradley K
The use of geotextiles in a range of civil engineering
applications is described. In the UK, the market is split
roughly 65:35 between non-woven and woven products,
with between 60 and 70 different types of geotextiles
falling into between 5 and 10 broad categories. Their use
is examined with respect to road widening projects,
landfill containment, and revetment applications. A need
for the establishment of European standards and common
test methods is stressed.
EUROPEAN COMMUNITY; EUROPEAN UNION; UK;
WESTERN EUROPE
Accession no.525763
**Item 225**

**High Performance Textiles**
Aug. 1994, p.11

**BIODEGRADABLE POLYPROPYLENE**

A degradable PP geotextile has been developed by F.Drake (Fibres) Ltd., which overcomes previous problems of excessive durability of PP. Brief details are given of the geotextile into which is incorporated a component whose addition can be controlled in order to adjust the rate of degradation.

DRAKE F., (FIBRES) LTD.
EUROPEAN COMMUNITY; EUROPEAN UNION; UK; WESTERN EUROPE
Accession no. 523533

**Item 226**

**Polymer**
35, No.10, 1994, p.2226-8

**LONG TERM PREDICTION OF CREEP IN TEXTILE FIBRES**
Bhuvanes Y C; Gupta V B
Indian Institute of Technology

The axial creep of a textile fibre produced from a blend of fibre-grade PP with 5 wt.% of commercial atactic PS was measured for 4h over a range of stresses and temperatures. Using a combined time-temperature-stress superposition principle, a master curve was constructed, taking the reference temperature as room temperature. The master curve was found to cover a period of over 120 years, which is the lifetime of some geotextiles used in reinforcing applications. 10 refs.

INDIA
Accession no. 522220

**Item 227**

**Polymer Degradation and Stability**
44, No.3, 1994, p.351-6

**EFFECT OF CARBON BLACK ON THE OXIDATION OF POLYOLEFIN; AN OVERVIEW**
Mwila J; Miraftab M; Horrocks A R
Bolton, Institute of Higher Education

The use of carbon black in polyolefins is widespread. Two to three percent of finely divided carbon black provides an effective light screen protecting the polymer against exposure to light. In geotextile applications, use of carbon black is widespread due to demands for higher durability. Types of carbon black, their usage and interaction with thermal antioxidants are reviewed. Current understanding of the effects of carbon black on the oxidation reaction shows conflicting evidence. Some workers have reported that carbon black accelerates oxidation due to surface catalysis of peroxide decomposition to form free radicals, adsorption of antioxidants from the polymer and increased accessibility of oxygen. Others have produced evidence of the inhibition of oxidation by carbon black because of its activity as a radical scavenger and its ability to decompose peroxides to form stable products. The role of reactive chemical groups on the carbon black surface, particle size and concentration are reviewed. 17 refs.

EUROPEAN COMMUNITY; EUROPEAN UNION; UK; WESTERN EUROPE
Accession no. 521851

**Item 228**

Philadelphia, Pa, 1992. 1/12/92. 9511T

**PRACTICE FOR DETERMINATION OF 2% SECANT MODULUS FOR POLYETHYLENE GEOMEMBRANES**
American Society for Testing & Materials
ASTM D 5323-

A technique is presented for determining the 2% secant modulus for PE geomembranes. This helps with modulus comparisons of similar materials. Photocopies and loans of this document are not available from Rapra. It may be purchased from BSI. Please contact Rapra for further details.

USA
Accession no. 521849
Item 231

Geotextiles and Geomembranes
13, Nos.6-7, 1994, p.475-93
FAILURE MODES AT MODEL TESTS OF A GEOTEXTILE REINFORCED WALL
Wong K S; Broms B B; Chandrasekaran B
Nanyang, Technological University; Bored Piling Pte.Ltd.

A series of model tests was conducted to study the failure modes of a geotextile reinforced soil wall. The reinforcement was a woven polyester with a strength of 47 kN/m and a stiffness of about 500 kN/m at 2% strain. A uniform surcharge pressure of up to 250 kPa was applied on top of the model. The observed failure modes are block sliding and slip failure. Other potential modes of failure are rupture of the reinforcements, bearing capacity and overall stability. The results do not support the pull-out and the overturning modes of failure. 18 refs.

SINGAPORE
Accession no.521566

Item 232

Geotextiles and Geomembranes
13, No.5, 1994, p.295-316
PULLOUT FORCE/DISPLACEMENT RELATIONSHIP OF EXTENSIBLE GRID REINFORCEMENTS
Bergado D T; Chai J-C
Bangkok, Asian Institute of Technology

A model for predicting the pullout resistance of polymer-grid reinforcement is proposed. The influence of bearing member rigidity and spacing ratio are expressed in the model. The displacement along the reinforcement was calculated by using the proposed pullout bearing resistance model together with the elongation of the grid longitudinal member. The validity of the method was confirmed by comparison of calculated values and actual test data. 8 refs.

THAILAND
Accession no.521168

Item 233

HDPE GEOMEMBRANES: TYPICAL PROBLEMS AND SOLUTIONS
Peggs I D
I-Corp International Inc. (SPE)

Failures in HDPE geomembranes caused by stress cracking, environmental stress cracking and delamination are examined, and resin selection, installation and quality control procedures aimed at overcoming such problems are reviewed. 12 refs.

USA
Accession no.520554

Item 234

HDPE GEOMEMBRANES: LINER CONSTRUCTION QUALITY ASSURANCE PRACTICES
Peggs I D; Steinele E R
I-Corp International Inc. (SPE)

Integrated quality programmes for the design and installation of HDPE geomembranes are discussed. 6 refs.

USA
Accession no.520553

Item 235

EVALUATION OF THE OXIDATIVE STABILITY OF POLYETHYLENE GEOMEMBRANES BY THE HIGH PRESSURE OXIDATIVE INDUCTION TIME TEST
Thomas R W; Ancelet C R; Brzuskiewicz J E
National Seal Co.; Heraeus Dset Laboratories Inc. (SPE)

The high pressure oxidative induction time test was used to study the oxidative stability of PE geomembranes containing different stabilisers and exposed to air oven ageing, fluorescent UV light, xenon arc UV light and warm water environments. 6 refs.

USA
Accession no.520551

Item 236

Geotextiles and Geomembranes
13, No.4, 1994, p.263-80
EXPANDED POLYSTYRENE (EPS) GEOFOAM: AN INTRODUCTION TO MATERIAL BEHAVIOUR
Horvath J S
Manhattan College

An overview is presented of the geotechnically relevant engineering properties of a specific geofoam expanded rigid PS. There is about 30 years experience of using it in geotechnical applications, primarily as thermal insulation and ultralightweight fill (its density is only about 1% of the density of soil). 18 refs.

USA
Accession no.518834
Item 237

Geotextiles and Geomembranes
13, No.4, 1994, p.231-46

YIELD OF SCRATCHED GEOMEMBRANES
Giroud J P; Beech J F; Soderman K L
GeoSyntec Consultants

It is demonstrated that geomembranes that have a stress-strain curve with a yield peak, such as HDPE geomembranes, yield at a tensile strain that is significantly influenced by scratches on the surface of the geomembrane. It is shown that scratched HDPE geomembranes can yield at strains that are one-third to one-half the yield strain of intact geomembranes. The method presented makes it possible to quantify the reduction in HDPE geomembrane yield strain due to scratches as a function of the scratch depth and the geomembrane thickness. Alternatively, the method can be used to select the thickness of an HDPE geomembrane for a given yield strain when a certain scratch depth is expected. 5 refs.

USA
Accession no.518833

Item 238

Geotextiles and Geomembranes
13, No.3, 1994, p.199-206

FOUNDATION ON STRONG SAND UNDERLAIN BY WEAK CLAY WITH GEOGRID AT THE INTERFACE
Khing K H; Das B M; Puri V K; Yen S C; Cook E E
Southern Illinois,University

A number of laboratory model test results for the ultimate bearing capacity of a surface strip foundation supported by a strong sand layer of limited thickness underlain by a weak clay with a layer of geogrid at the sand-clay interface are presented. Data are given for ethylene-propylene copolymer and PP geogrids. 4 refs.

USA
Accession no.517634

Item 239

Geotextiles and Geomembranes
13, No.3, 1994, p.181-97

MODELLING PERFORMANCE OF A SLOPED SOIL WALL USING CREEP FUNCTION
Lopes M L; Cardoso A S; Yeo K C
Oporto,University; Hong Kong,Geotechnical Engineering Office

A rheological model based on a series of Kelvin models for analysing creep behaviour is described for analysing polymer reinforced soil structures. The performance of the numerical model and the actual behaviour of the structure are compared. 7 refs.

EUROPEAN COMMUNITY; EUROPEAN UNION; HONG KONG; PORTUGAL; WESTERN EUROPE
Accession no.517633

Item 240

Geotextiles and Geomembranes
13, No.3, 1994, p.165-79

MODIFIED DIRECT STUDY OF CLAY LINER-GEOMEMBRANE INTERFACES EXPOSED TO LANDFILL LEACHATE
Masada T; Mitchell G F; Sargand S M; Shashikumar B
Ohio,University

Direct shear tests were used to quantify interface friction existing within the multi-layer solid waste landfill system. Modified direct shear tests were performed for interfaces between compacted clay and smooth HDPE, textured HDPE, and smooth PVC geomembranes. 13 refs.

USA
Accession no.517632

Item 241

Geotextiles and Geomembranes
13, No.3, 1994, p.133-45

IMPACT OF PRODUCT STRUCTURE ON THE STABILITY AND DURABILITY OF COATED PETP GEOGRIDS
Duvall D E
Broutmann L.J.,& Associates

Four commercial coated PETP geogrids were studied in order to assess characteristics such as polymer coating type, coating thickness and uniformity, fibre diameter, and fibre distribution within the coated bundles. Certain anomalies in the geogrids are discussed with reference to durability. 9 refs.

USA
Accession no.517631

Item 242

Polymer and Fibre Science: Recent Advances.

FLUID FLOW THROUGH NEEDLE-PUNCHED GEOTEXTILE FABRICS
Chahal V; Buchanan D R; Mohamed M H
North Carolina,State University
Edited by: Fornes R E; Gilbert R D; Mark H F
(North Carolina,State University)

Needle-punched nonwoven fabrics made from crimped polyester staple fibres were studied under high normal pressures, both in the transplanar and the in-plane flow permeameters using a specially modified apparatus. Fibre diameter was the most important fabric parameter to be considered when designing needle-punched nonwovens for fluid transmission under Darcian flow conditions. A strong correlation was observed between fibre linear density and fabric permeability. The second most important factor was the normal pressure under which the fabrics were confined during the flow. This reflects the structural changes that occur on external loading and that alter the internal pore size distribution, and hence
the permeability coefficient. A significant difference was observed between fabrics made of fine fibres (6 and 9 denier) and those made of coarse fibres (45 denier). A strong linear correlation was observed between fabric permeability and thickness under the experimental stresses. For this reason, the constitutive material behaviour of the fabric under load can be a good indicator of its behaviour toward fluid flow. 23 refs.

USA
Accession no.516482

Item 243
High Performance Textiles
May 1994, p.8-9
*TREVIRA* SEA DEFENCES: A CASE STUDY

A revetment was built to replace the sea walls at Rhos-on-Sea, which were below standard and posed a risk of flooding, using rocks, and consisting of a gradual incline of primary armour and core material. To prevent erosion, a Trevira polyester spunbond geotextile was specified to act as a filter/separation layer which was mechanically bonded to the boulders. Above this was laid a woven Scotlay and a bedding layer on which the boulders could be placed. Further construction details are described.

MCALPINE A.,CONSTRUCTION LTD.; MONOMET LTD.
EUROPEAN COMMUNITY; UK; WESTERN EUROPE
Accession no.514280

Item 244
Polymer Plastics Technology and Engineering
33, No.3, April 1994, p.281-93
DURABILITY CONSIDERATIONS FOR PVC FORMULATIONS USED IN GEOSYNTHETICS: A REVIEW
Kamykowski G W
Broutman L.J.,& Associates Ltd.
The types of degradation which PVC could experience in geosynthetic applications (e.g. geogrids, geomembranes) at various stages of its useful life are discussed, including degradation during storage prior to use, installation and exposure to its surroundings, both above ground and underground. Photodegradation, plasticiser loss, short-term physical breakdown and long-term physical breakdown are considered. Summaries are given of representative literature articles on general durability studies, UV radiation effects and biological studies. 14 refs.

USA
Accession no.514146

Item 245
Plastics and Rubber Weekly
No.1526, 11th March 1994, p.12
DOLCI PLUGS A GAP WITH NINICAST

Dolci is offering its new Ninicast 1500mm multipurpose cast film line for use where blown film lines would be too complex or conventional cast film equipment unprofitable. The company is aiming its compact 70KRC extruder at the small to medium sized user. Dolci has been concentrating upon the technology of winding, chiefly in respect of cast film and geomembrane applications. Dolci has also supplied coextrusion lines for the production of thick film for geotechnical uses and waterproofing anti-pollution installations.

DOLCI EXTRUSIONS
EUROPEAN COMMUNITY; ITALY; WESTERN EUROPE
Accession no.509338

Item 246
Plastics and Rubber Weekly
No.1526, 11th March 1994, p.10
SHAPING UP FOR A NEW RESPONSIBILITY
Coulson J

Geomembranes are used for a variety of applications including liners for lakes and reservoirs, as well as effluent treatment facilities and for isolating ground contamination or landfill. The radial dye extrusion method of producing wide width sheet provides membranes with the necessary strength and qualities for these environmentally sensitive applications. In 1991, SGS Geosystems installed a purpose-built, state of the art, production process at its Soham, Cambridgeshire, factory. It was found that a medium density PE copolymer with a reference density of 0.939 g.cm and a wide molecular weight distribution was particularly suited for the production of geomembranes. Production at the SGS site is outlined.

SGS GEOSYSTEMS
EUROPEAN COMMUNITY; UK; WESTERN EUROPE
Accession no.507880

Item 247
Geotextiles and Geomembranes
13, No.1, 1994, p.119-26
FAILURE CRITERIA FOR TWO-DIMENSIONAL ORTHOTROPIC FIBROUS COMPOSITES OF LOW BENDING STIFFNESS

Exxon Chemical Geopolymers Ltd.
Applications are described of the Exxon Chemical range of soil reinforcement geotextiles. The selection of Terram products for short-, medium-, and long-term applications is discussed. Products include nonwoven thermally bonded sheet materials and high strength composite materials for structural applications.

EUROPEAN COMMUNITY; UK; WESTERN EUROPE
Accession no.507880
Minster J
Czech Republic, Academy of Sciences

An analysis is presented of the objective quadratic criteria of failure of two-dimensional orthotropic fibrous composites of low bending stiffness with a secondary condition excluding compressive strength. The possible forms of theoretical strength prediction are compared with experimental results for a PVC coated polyamide geotextile. 6 refs.
CZECH REPUBLIC
Accession no.506438

Item 249
Geotextiles and Geomembranes
13, No.1, 1994, p.91-9
EFFECTIVENESS OF A REINFORCING GEOGRID IN A RAILWAY SUBBASE UNDER DYNAMIC LOADS
Gobel C H; Weisemann U C; Kirschner R A
Dresden, Technische Universität; Huesker Synthetic

Details are given of the deformation characteristics of a railway loadbearing system with and without a geogrid. The geogrid was made from a PVC coated saturated polyester.
EUROPEAN COMMUNITY; GERMANY; WESTERN EUROPE
Accession no.506437

Item 250
Geotextiles and Geomembranes
13, No.1, 1994, p.67-89
UPLIFT BEHAVIOUR OF PLATE ANCHORS WITH GEOSYNTHETICS
Krishnaswamy N R; Parashar S P
Indian Institute of Technology

The uplift behaviour of plate anchors embedded in cohesive and cohesion-less soil media, with and without geosynthetics was investigated. Data are given for HDPE geogrids. 23 refs.
INDIA
Accession no.506436

Item 251
Geotextiles and Geomembranes
13, No.2, 1994, p.55-64
EFFECT OF DYNAMIC LOADING ON COMPRESSIONAL BEHAVIOUR OF SPUNBONDED NONWOVEN FABRICS
Kothari V K; Das A
Indian Institute of Technology

The change in compressional behaviour with dynamic loading was studied for spunbonded nonwoven geotextiles. The compressibility of thermally bonded spunbonded fabrics was compared with that of several types of spunbonded needle punched fabrics. 4 refs.
INDIA
Accession no.506435

Item 252
Geotextiles and Geomembranes
13, No.2, 1994, p.43-54
FINITE ELEMENT MODELLING OF PULL-OUT TESTS WITH LOAD AND STRAIN MEASUREMENT
Yogarajah I; Yeo K C
Strathclyde, University

Details are given of the load and strain distributions along a geogrid reinforcement during a pull-out operation. Loads and strains along various sections of the geogrid reinforcement were measured at different pull-out displacements, with respect to different anchorage lengths. Numerical modelling was then carried out to simulate the operation. Comparisons between the measured and simulated load and strain distributions are presented. 11 refs.
EUROPEAN COMMUNITY; UK; WESTERN EUROPE
Accession no.506434

Item 253
Geotextiles and Geomembranes
MATHEMATICAL MODEL OF GEOMEMBRANE STRESS-STRAIN CURVES WITH A YIELD PEAK
Giroud J P
GeoSyntec Consultants

A mathematical model is proposed to describe the stress-strain curves of geomembranes, such as HDPE, that exhibit a yield peak in a uniaxial tensile test. The model was calibrated with results of uniaxial tensile tests conducted with smooth HDPE geomembranes. 3 refs.
USA
Accession no.506433

Item 254
High Performance Textiles
Feb.1994, p.5
PUNCTURE-RESISTANT NEEDLEFELT
Geofabrics has introduced a geotextile designated Protector 50. The product is a 4mm thick needleflet of 500gsm, designed specifically to offer excellent puncture resistance. The bulk of fabrics made by the company are based on PP as this is largely chemically inert. If improved chemical resistance is required as, for instance, with chemical leachates, then fabrics are also made using HDPE. Details are given.
GEOFABRICS LTD.
EUROPEAN COMMUNITY; UK; WESTERN EUROPE
Accession no.504159
It is briefly reported that the cores of miniature borehole packers used by the British Geological Survey are made from high-extension, abrasion-resistant tubes supplied by Dunlop Precision Rubber. The tubes are made in a highly flexible rubber which can be inflated to above the environmental pressure inside the borehole for sealing tightly against the sides. A major investigation of how water and water soluble pollutants travel through limestone rock is being carried out and twelve 18-metre deep 4-inch diameter boreholes have been drilled.

**DEALING WITH WASTE BREAKS NEW GROUND**

Gupta N

Stricter methods required to deal with hazardous waste are reported from the Asia-Pacific region, where, until recently, hazardous waste was dumped directly into the sea. The use of geotextiles, geomembranes, geosynthetic clay liners and geomatrices in landfill applications is discussed, with details of the size of the market and opportunities for growth. It is expected, however, that by the year 2002, incineration will be widely accepted as the waste processing technology of choice.

**AGRICULTURAL PROJECT USES SCRAP TYRES**

Moore M

Shredded scrap tyres are being used in a ‘Hydro-Culture’ application by Entire Environmental Systems Inc. The shredded or cubed tyres are placed under a geotextile lining to form a reservoir for use in an experimental waterborne plant nursery at Hutchins, Texas. Details of the project are described.

**SCRAP TYRES IRRIGATION SYSTEM TO CREATE HIGH-YIELD NURSERY**

Moore M

It is reported that more than 1.2 million scrap tyres are going into an experimental, water-borne plant nursery which, according to its developer Entire Environmental Systems Inc, can increase agricultural yields by 50 to 120%. The Enclosed Hydraulic Irrigation System, or Hydro-Culture, makes use of shredded or cubed and baled tyres layered under a geotextile lining to create an underground reservoir. Details are given.

**FABRICATOR BOOSTS QUALITY WITH SPEEDY SEAM TEST**

Callari J

Environmental Protection Inc., a fabricator of PVC geomembrane liners, has developed a process that permits it to test the integrity of a welded seam within 5 minutes. The Wolschon Test directly correlates with the ASTM’s and NSF’s standards for testing weld-seam integrity, which requires that samples be brought from the production floor into the lab to acclimate for 40 hours, allowing the seam to cure, before peel-strength tests are done. The end result of the accelerated test is that EPI can correct flawed seams about 10 minutes after they are made, instead of nearly three days later. Samples are pulled from the production process and after 5 minutes tested for peel strength in a tensiometer.

**INTERFACIAL FRICTION IN SAND-GEOTEXTILE COMPOSITES**

Athanasopoulos G A; Bousias P Z

Patras, University

Edited by: Paipetis S A; Papanicolaou G C (Patras, University)

The results of direct shear tests on dry Ottawa sand reinforced with sheets of geotextiles embedded normally to the shear plane are used to determine the apparent friction angle at the sand-geotextile interface. Parameters investigated include the interface normal stress and the thickness and type (woven or non-woven) of the geotextile. 14 refs.
**Item 261**

*Journal of Plastic Film & Sheeting*

9, No.3, July 1993, p.171

**NEW GEOMEMBRANE RESIN FROM NOVACOR**

This is a medium-density PE, designated HD-2070-A, that is easily processable on blown and cast extrusion systems.

NOVACOR CHEMICALS INC.

USA

Accession no.494096

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**Item 262**

Lancaster, Pa., 1992, pp.1. 11ins. 14/4/93. 625-6L6

**REGUOPOL 7513CS, PRODUCT DATA**

Dodge-Regupol Inc.

Properties are presented for Regupol 7513CS, one of a family of products made from recycled rubber fibres mixed with a custom formulated PU binder. Regupol is compression moulded into sheets or rolls and is designed for use in geomembrane protection, tank and pipe bedding and for the damping of sound and vibration.

USA

Accession no.493762

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**Item 263**


Conference Proceedings.

Detroit, Mi., 3rd-7th May 1992, p.128-31. 012

**CREEP AND STRESS RUPTURE TESTING OF PE SHEET UNDER EQUAL BIAXIAL TENSILE STRESSES**

Duvall D E; Edwards D B

Broutman L J, & Associates Ltd.

(SPE)

A method for evaluating the creep and stress rupture response of PE sheet under equal biaxial loading is presented and applied to a study of a MDPE geomembrane liner. Creep data, accumulated at 23°C and several stress levels for nearly 8000h, are presented in the form of a set of isochronous stress-strain curves. Stress rupture testing at 60 and 80°C gives data for estimating time for failure under constant stress at temps. to which the product will be exposed in service. 14 refs.

USA

Accession no.483808

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**Item 264**

*Plastics World*

51, No.6, June 1993, p.12

**NEW CATALLOY LINE OFFERS EXPANDED PRODUCTIVITY**

New Catalloy olefinic polymers from Himont, a family of 20 resins based on two or three olefin monomers, can be processed via air-quenched blown film, cast film, extrusion coating, injection moulding, blow moulding, sheet extrusion, coextrusion and calendering. Over six million square feet of calendered Catalloy polymer have already been installed as geomembrane liners for landfills or at other sites where moisture containment is required. Another target market for Catalloy materials is packaging. One early application is the heat seal layer for BOPP film. Other applications include heavy-duty industrial bags and blow moulded bottles.

HIMONT INC.

USA

Accession no.480108

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**Item 265**

*High Performance Textiles*

May 1993, p.14

**DEPRESSION US GEOTEXTILES**

It is briefly reported that consumption of geotextile fabrics in the USA and Canada will be much the same in 1992 as in 1991. In 1991 consumption was some 295 million square metres, rising to only 312 million square metres in 1992. According to a report by the Industrial Fabrics Association International, growth of geotextiles is predicted to be only about 5% between 1992 and 1993. Consumption of geomembranes in 1992 was estimated to be 54 million square metres, rising in 1993 to 68 million square metres.

US, INDUSTRIAL FABRICS ASSN. INTERNATIONAL

USA

Accession no.479897

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**Item 266**

*British Plastics and Rubber*

April 1993, p.36

**FILM BLOWING ON A HUGE SCALE**

It is reported that one of the biggest blown PE film lines in Europe is up and running at Satellite Geosystems of Soham, Cambridgeshire. Using a 25m high bubble, it is producing a 5.7m wide black PE sheeting, for lining lagoons and reservoirs, landfills and isolating ground contamination. Very brief details are noted.

SATELLITE GEOSYSTEMS EUROPEAN COMMUNITY; UK; WESTERN EUROPE

Accession no.475258

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**Item 267**


Nottingham, 9th-10th July 1991, Paper 10. 93

**GEOTEXTILES IN AGGRESSIVE SOILS**

Greenwood J H; Brady K C

ERA Technology Ltd.; UK, Transport & Road Research Laboratory

(PRI)
Potential causes of degradation of polymers in the soil are briefly discussed and the results of tests performed using geotextiles based on PP fabric and various backfills to establish the extent of damage caused during compaction of the surrounding soil are presented. Partial factors of safety for installation damage that could be used in the design of reinforced soil structures are also considered. 8 refs.

EUROPEAN COMMUNITY; UK; WESTERN EUROPE
Accession no.474113

Item 268
Plastics and Rubber Weekly
POLYMER GEOTEXTILES DEGRADATION PROOF

According to the latest research from the Transport Research Laboratory, polymer geotextiles are resistant to degradation in most sub-soil environments. The latest studies are claimed to show that in general, geotextiles have excellent resistance to the conditions found in most UK soils, except in cases of extreme acidity or alkalinity, sometimes found with very ‘green’ concrete or landfill sites. Brief details are noted.

UK,TRANSPORT RESEARCH LABORATORY
EUROPEAN COMMUNITY; UK; WESTERN EUROPE
Accession no.472254

Item 269
Plastics and Rubber Weekly
BREAKTHROUGH IN FORMALDEHYDE-FREE BUILDING MATERIAL

Rohm & Haas is reported to have claimed a major breakthrough in the move to remove formaldehyde-based materials from flooring, roofing and geotextiles. A new product will be unveiled in the spring of 1993 at the international Index ’93 exhibition in Geneva; the company is to launch a range of all-acrylic resins to replace formaldehyde in the bonding of non-woven glass fibre web reinforcing. Brief details are noted.

ROHM & HAAS CO.
EUROPEAN COMMUNITY; SWITZERLAND; UK; WESTERN EUROPE
Accession no.472251

Item 270
Plastics World
BIG BUSINESS IS GETTING WIDER

Callari J

SLT Environmental recently installed at its plant in Germany what might be the largest flat-die extrusion system in operation today, a 24 ft wide geomembrane liner system. The company claims that coextrusion allows it to combine various types of PE in a given structure, while permitting more economical use of colourants and/or stabilisers. The line is equipped with automatic die bolt adjustments which hold gauge to within plus/minus 2-3%, it is claimed.

SLT ENVIRONMENTAL
EUROPEAN COMMUNITY; GERMANY; WESTERN EUROPE
Accession no.472004

Item 271
High Performance Textiles
Jan.1993,p.3
GEOTEXTILE FOR ROADS FROM DON AND LOW

A woven PP geotextile called Pavelay has been introduced by specialist textile maker Don & Low Ltd. The fabric is laid over a preliminary tack coating before the normal overlay is applied to a road or pavement. Brief details are given.

DON & LOW LTD.
EUROPEAN COMMUNITY; UK; WESTERN EUROPE
Accession no.469940

Item 272
Rubber and Plastics News
22,No.10,7th Dec.1992,p.12
OLD TYRES FINDING USE UNDER ROADS, BUILDINGS

Moore M

Prospect Enterprises Inc. has patented a way to use rubber under both roads and buildings as a drainage quilt which consists of scrap tyre chips or chunks tied between two geotextile blankets. This provides drainage for buildings and roads that is both cheaper and environmentally safer than traditional gravel or crushed stone. Scrap tyres are also less expensive for construction drainage than gravel. A detailed account is given of the development and use of the drainage quilts.

PROSPECT ENTERPRISES INC.
USA
Accession no.467392

Item 273
Rubber and Plastics News
22,No.9,23rd Nov.1992,p.6
RECYCLED RUBBER FINDS NEW USE AT LANDFILL

Garrett A

Dodge-Regupol of the USA commenced testing Regupol cushions as a protective layer for the lining of landfills in November 1992, with a 100,000 US dollars grant from Pennsylvania’s environmental research fund. If successful, a thin layer of Regupol - made from recycled rubber - could be used to cushion a landfill’s geomembrane. Details are given.

DODGE-REGUPOL INC.; DODGE CORK CO.; BERLEBURGER SCHAUMSTOFFWERK GMBH
USA
Accession no.464532

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Item 274

Modern Plastics International
22, No.11, Nov. 1992, p. 84

GEOMEMBRANES TO BE A MAJOR SHEET MARKET IN EUROPE

A new report from Chem Systems assesses the sheet market in Europe, created by environmental regulations, for geomembranes - thick sheet with nonwoven fabric backings, typically laid down to prevent erosion, or to contain pollution from landfill or other sites. The report analyses the market in 16 countries and reviews the cost of production for each membrane type. The report also describes business structure and codes of practice.

CHEM SYSTEMS LTD.
EUROPEAN COMMUNITY; UK; WESTERN EUROPE;
WESTERN EUROPE-GENERAL
Accession no. 462947

Item 275

European Plastics News
Nov. 1992, p. 55-6

KUHNE MEETS WIDER DEMANDS OF GEOMEMBRANE MARKET

The use of polymer geomembranes is growing in environmental protection applications. In particular, consumption of HDPE geomembranes for use in landfill waste sites is increasing rapidly. The industry is aiming to reduce leakage through the use of wider webs and Kuhne, extrusion machinery builder, has constructed a 5.8 metre wide geomembrane extrusion line, which it claims is the largest to be built in Europe. The production line, which has been used to produce a range of webs in thicknesses ranging from 1.5 to 4mm, is outlined.

KUHNE GMBH
GERMANY
Accession no. 460916

Item 276

Modern Plastics International

VERY-LOW-DENSITY PE

DSM Resins has introduced Teamex which has a density of 0.9 g/cubic cm. The PE resin is intended for production of strong flexible sheet and applications include special packaging films and geomembranes. This abstract includes all the information contained in the original article.

DSM RESINS BV
EUROPEAN COMMUNITY; NETHERLANDS; WESTERN EUROPE
Accession no. 459464

Item 277

New Scandinavian Technology

BREAKTHROUGH IN HIGH-STRENGTH FIBRE

Danaklon and Neste have joined together in a Eureka project to develop different categories of fibre: soft, hydrophilic, non-fibrillating radiation resistant fibres for use in the medical industry; geotextiles; and fibres for spinning. The work has resulted in a thermobondable PP fibre called HY-Strength, and a fibre for use in disposable medical materials. Also, they have developed a process to produce a high strength fibre that is stronger than conventional fibres.

DANALKON AS; NESTE OY
DENMARK; EUROPEAN COMMUNITY; FINLAND;
SCANDINAVIA; WESTERN EUROPE
Accession no. 458342

Item 278

Plastics News (USA)
4, No. 1, 2nd March 1992, p. 2

SLT TO MAKE GEONET MATERIALS

Bregar B

SLT North America, a maker of geomembrane liners, will expand into production of geonet materials this spring. The SLT product will be made by extruding HDPE through counter-rotating dies. Used in lining systems for ponds and landfills, geonet acts as a channel to drain leaking liquids to a central collection point.

SLT NORTH AMERICA INC.
USA
Accession no. 453733

Item 279

New Materials/Japan
June 1992, p. 15

FIBRE FOR REINFORCING SOIL FROM ASAHI CHEMICAL

Asahi Chemical Industry Co. has developed ‘Power Grid’ a reinforcing material based on polyacetal fibre, for use in stabilising soil on slopes and other erosion prone areas. Brief details of the production of the polyacetal fibre are supplied together with details of its tensile properties.

ASAHI CHEMICAL INDUSTRY CO., LTD.
JAPAN
Accession no. 451181

Item 280

Plastics and Rubber Weekly
No. 1427, 21st March 1992, p. 16-7

EXTRUSION PLANT SPECIALLY BUILT FOR MOTAN SYSTEM

A new extrusion plant built for Alois Gruber (Agru) which has been purposely designed to accommodate an extensive Motan materials handling system is described. Agru produces HDPE sheet for land membranes, and pipes in PE, PP and PVDF. The Motan units were chosen chiefly because of the ease of use of the touch screen microprocessor control system.
GRUBER A. & SOHN OHG
AUSTRIA; WESTERN EUROPE
Accession no.444794

Item 281
Plastics and Rubber Weekly
No.1422,15th Feb.1992,p.4
BRIGHT ROAD AHEAD FOR GEOSYNTHETICS

According to Chem Systems, geosynthetics offer bright growth prospects, as road repairs using geotextile techniques already established in North America penetrate the European market. Many civil engineering projects now use plastic Geogrids for soil stabilisation and river bank protection; brief details of a survey are presented.

CHEM SYSTEMS INTERNATIONAL LTD.
EUROPEAN COMMUNITY; UK; WESTERN EUROPE;
WESTERN EUROPE-GENERAL
Accession no.439697

Item 282
San Diego,Ca.,15th-18th April 1991,p.1939-49. 012
GEOPOLYMER. ULTRA-HIGH TEMPERATURE TOOLING MATERIAL FOR THE MANUFACTURE OF ADVANCED COMPOSITES
Davidovits J;Davidovics M
CORDI-GEOPOLYMERE SA
Edited by: Stinson J;Adsit R;Gordaninejad F
(SAMPE)

Geopolymers of the poly(sialate-disiloxo) type are very low viscosity inorganic resins which harden like thermosetting organic resins, but have a useful temp. range up to 1000C. Geopolymers provide faithful reproduction of the mould or die surface and allow for precision and fineness. Geopolymer reinforced with glass or carbon fabrics can be used up to 450C, but silicon carbide (Nicalon) or aluminium oxide (Safil) fibres are needed for higher temps. Thermal expansion coefficients are similar to those of thermoplastic composites and make the geopolymers suitable as tooling materials for reinforced thermoplastic processing. Examples relate to use of geopolymers (Geopolymite and Geopolyceram) for tools to prepare PEEK and PPS composite aircraft parts. 12 refs.

EUROPEAN COMMUNITY; FRANCE; WESTERN EUROPE
Accession no.436001

Item 283
High Performance Textiles
Oct.1991,p.13-4
PROTECTING AN INDIAN ESTUARY WITH GEOTEXTILES

The Calcutta Port Trust is building a 2800m long guide wall on the River Hugli, to improve the draught of the river. This complex task is nearing completion and problems encountered are outlined. The wall is built on a geomattress to protect the river bed. The construction of this is described. Two geotextiles were used in it. A woven fabric was placed beneath a non-woven fabric and stitched to it, using PP thread, thus combining the high tensile strength of the woven fabric with the good filtration properties of the non-woven one. Properties of the fabrics are discussed.

INDIA,CALCUTTA PORT TRUST
EUROPEAN COMMUNITY; INDIA; NETHERLANDS;
WESTERN EUROPE
Accession no.435246

Item 284
Asian Plastics News
Sept.1991,p.27-8
GIANT HDPE SHEETS LINE THE WAY AHEAD

In June, Kuhne ran the first live trials on its giant 5.8m wide extrusion line, believed to be the widest HDPE sheet line in the World. The giant geomembrane sheets are used to line landfill waste disposal sites. In general, the sheets used must be physically strong, resistant to chemicals and as wide as possible to cut down on the need for welded seams which are a natural weak point in the seal.

KUHNE GMBH
GERMANY
Accession no.434397

Item 285
Composites Plastiques Renforces Fibres de Verre
Textile
31,No.2,March/April 1991,p.76-89
GEOPOLYMER INORGANIC RESINS, THEIR USES IN THE COMPOSITE INDUSTRY
Davidovits J;Davidovics M;Orlinski J
FRANCE,GEOPOLYMER INSTITUTE
(In French and English). The properties of geopolymers and their use in the composite industry are described in detail. Geopolymers are synthetic alumino-silicate binders which produce ceramic-like objects, either by agglomeration of fillers or by impregnation of fibres or fabrics. The chemical composition of geopolymers is described in detail. The non-toxic and fire resistance features of geopolymer matrix composites are identified and the use of geopolymer resins in tooling for fabrication of other advanced composites is outlined.

EUROPEAN COMMUNITY; FRANCE; WESTERN EUROPE
Accession no.434384

Item 286
SPI Composites Institute s 46th Annual Conference.Conference Proceedings.
Washington,DC,18th-21st Feb.1991,Paper 12-D/1-12-
D/7. 627
APPLICATION OF FRP GRID
REINFORCEMENT FOR CONCRETE AND SOIL
FRP grids have been recently developed. They possess sufficient anchorage to concrete and soil, are non-corrosive, lightweight, and non-magnetic. The manufacturing process is described along with the material properties and the grid’s reinforcing effect on concrete and soil. Some applications for concrete and soil structures are described. 7 refs.

JAPAN
Accession no.433457

Item 287
Plastics Southern Africa
21, No.1, June 1991, p.8/14
GEOSYNTHETICS IN CIVIL AND MINING ENGINEERING
Dickson M G
INDUSTEX HOLDINGS (PTY.) LTD.

The use of geotextiles (permeable synthetic membranes used in civil engineering works) is growing rapidly. They can be woven, non-woven or knitted fabrics; or, in a recent development, a composite of the three. This technical review picks out four general applications: drainage, where composite geotextiles remain effective under pressure in reducing pore-water pressure; ground-water filtration, where mesh can be matched to the fines and thus prevent clogging of filters; the keeping apart of two materials which would otherwise mix; and the reinforcement of foundation soil to help eliminate any tensile stresses. The author discusses problems regarding testing of geotextiles in this and an accompanying article.

SOUTH AFRICA
Accession no.432468

Item 288
Plastics Southern Africa
21, No.1, June 1991, p.14/6
GEOSYNTHETICS: WHY THE NEED FOR ACCURATE TESTING?
Dickson M
INDUSTEX HOLDINGS (PTY.) LTD.

Where geotextiles are used to transport water along their planes, for instance in a blanket drain in a dam, the behaviour between two soil layers was found to be very different from predictions from tests between steel plates under lateral pressure. This difference in behaviour could lead to catastrophic failure. The provision of better real performance data is called for, with closer collaboration between civil engineers and manufacturers of geotextiles. 17 refs.

SOUTH AFRICA
Accession no.432467

Item 289
ICI Advance
No.7, 1991, p.13
PAVING THE WAY
ICI, ADVANCED MATERIALS

A high strength PP mesh has been developed and is being used in the Yorkshire Dales National Park to strengthen heavily-used footpaths which have become eroded. The mesh is laid directly on the peat soil, without damaging its structure, and building aggregate is then placed on top to create a tough, hard-wearing, free-draining surface which should need no major maintenance for approximately 20 years.

NETLON LTD.
EUROPEAN COMMUNITY; UK; WESTERN EUROPE
Accession no.431189

Item 290
Denver, Co., c.1989, pp.6. 12 ins. 11/5/89. 42C11-6L2-93511
LEAKAGE MONITORING OF THE GEOMEMBRANE LINER FOR THE PROTON DECAY EXPERIMENT. PAPER PRESENTED AT THE INTERNATIONAL CONFERENCE ON GEOMEMBRANES, SESSION 5B, P.475-80, HELD DENVER, USA
Stone J L
MICHIGAN, UNIVERSITY

Zero leakage requirement of a reservoir located in a salt mine extending under Lake Erie, necessitates the secure long term containment of pure water in a lined facility, and accurate monitoring and quality control procedures. The main problems encountered with the HDPE liner are discussed and stress concentration at geomembrane thickness discontinuities e.g. seams, are believed to be the primary cause of observed failures. Protons in the water are monitored by photomultiplier tubes immersed in the water to observe any decay or spontaneous decay of the proton. Details are given of the liner installation and its performance, quality control procedures and leakage monitoring systems. 5 refs.

USA
Accession no.430413

Item 291
Construction & Building Materials
5, No.2, June 1991, p.63-7
GEOTEXTILE/COVERING PAD REINFORCING SYSTEM
Patel N M
BARODA, UNIVERSITY

Laboratory studies on glass fibre geotextiles placed at some depth in a virgin soil deposit with frictional sand placed above the geotextile are first reported. Results are compared with tests conducted without geotextile. A parametric study is then reported conducted on the geotextile/covering pad
Different types of virgin sand, covering pad sands and reinforcing textiles were used. Different friction tests were used for various combinations of covering sand/geotextile/virgin sand. 8 refs.

**Item 292**


**FLEXOMER POLYOLEFINS: A BRIDGE BETWEEN POLYETHYLENE AND RUBBER**

Rifi M R; Ficker H K; Corwin M A

UNION CARBIDE CHEMICALS & PLASTICS CO. INC.

(ACS, Rubber Div.)

Flexomer polyolefins are described as having a combination of toughness and flexibility which bridges the gap between PE and rubbers. Applications in film, foam, hose, tubing, wire and cable, geomembrane and as modifiers are cited. Thermoplastic polyolefins based on Flexomer blends with isotactic PP were compared with blends of PP and EPDM and PP/in-situ reactor impact modifier blends. 7 refs.

**USA**

Accession no. 428368

**Item 293**

**High Performance Textiles**

May 1991, p. 8-9

**GEOTEXTILES REDUCE CONSTRUCTION COST**

Details are given of Fritz Landolt AG’s Textomur-System geotextile reinforcement, which is used as an alternative to concrete in the construction of steep embankments. The reinforcement, which is based on a polyester non-woven fabric, provides drainage and permits vegetation to grow over the bank.

LANDOLT F., AG

SWITZERLAND; WESTERN EUROPE

Accession no. 427958

**Item 294**

**Sports Industry**


**PLASTIC GRID CAN SAVE REAL TURF**

The inclusion of small plastic grids to a depth of between four and eight inches below a natural turf surface can halve divot recovery times. The Techurf mesh element system is incorporated within a sand-based mix which gives three dimensional support to the sand layer, leading to increased loadbearing capacity and stability.

TEXAS A & M UNIVERSITY

USA

Accession no. 428456
the sheets can resist stress cracking much better than the seams.
USA
Accession no.427913

Item 299
Rail Bull.
3,No.3,Summer 1991,p.64
GEOTEXTILES IN RAILWAY APPLICATIONS
Geotextiles are commonly used in the area of preventing track pumping (penetration of the track bed from below by a slurry of fine particles and water which effectively reduces the bearing capacity of the ballast and can cause loss of material from the sub-grade). Lotrack is a composite PP woven geotextile made from a PP fleece, needle punched onto a woven base. It has been incorporated to control erosion pumping by British Rail in a number of locations. A brief description is given of its use, including a case history.
DON & LOW PLC
EUROPEAN COMMUNITY; UK; WESTERN EUROPE
Accession no.427319

Item 300
St.Paul,Minnesota, 1988, pp.8. 12ins. 11/5/89. 6L2-8(12)1
FAILURE AND REPAIR OF GEOMEMBRANE LINING SYSTEM
Peggs I D
HANSON MATERIALS ENGINEERING
This is a short report discussing the failure of a geomembrane lining system in West Canada and the consequent repair of the lining.
USA
Accession no.425246

Item 301
High Performance Textiles
March 1991,p.7-8
GEOTEXTILES USED IN WATER-RETAINING EMBANKMENTS
Results are presented of studies of the performance of geotextiles used in the construction of temporary and permanent water-retaining embankments for the James Bay Hydroelectric Project in Canada. The basic requirements of geotextiles used as filters in coffer-dams and as separators for upstream dam-shells are considered.
ECOLE POLYTECHNIQUE DE MONTREAL;
SHAWINIGAN-LAVALIN CANADA
Accession no.423283

Item 302
Construction & Building Materials
5,No.1,March 1991,p.45-8
EXPERIMENTAL AND FINITE ELEMENT ANALYSIS ON BEARING CAPACITY OF GEOSYNTHETIC REINFORCED SAND
Mandal J N;Mhaiskar S Y;Manjunath V R
INDIAN INSTITUTE OF TECHNOLOGY
The effect of the depth of placement on the bearing capacity ratio of geosynthetic reinforced sand was studied, the geotextile being a needle-punched non-woven material based on PP fibres. Experimental and finite element method approaches were used. Close agreement was found between the two approaches. A depth of placement/width of foundation ratio of 0.25 was found to be optimum. 8 refs.
INDIA
Accession no.422328

Item 303
New Scientist
130,No.1770,25th May 1991,p.38-42
SAVING MUD MONUMENTS
Dayton L
A detailed description is given of experiments relating to the preservation of adobe using additives which include polymeric materials, e.g. acrylic polymers, and geotextiles, e.g. PP fabric.
EUROPEAN COMMUNITY; UK; WESTERN EUROPE
Accession no.422278

Item 304
GEOSYNTHETICS
Lawson C R
EXXON CHEMICAL GEOPOLYMERS LTD.
Edited by: Hollaway L C
(Institution of Civil Engineers)
Geotextiles and impermeable polymeric membranes are categorised. Their material types and characteristics are outlined, together with some properties of synthetic fibres. Applications in filtration, sub-surface drainage, erosion control, use of geotextiles as forms, separation layers, soil reinforcement, and containment, are given. 46 refs.
EUROPEAN COMMUNITY; UK; WESTERN EUROPE
Accession no.421234

Item 305
Journal of Coated Fabrics
20,Oct.1990,p.82-7
USE OF POLYPROPYLENE NON WOVEN GEOTEXTILES IMPREGNATED WITH BITUMINOUS BINDER IN ROAD PAVEMENTS
Levy T
DU PONT DE NEMOURS (LUXEMBOURG) SA
Non-woven geotextiles impregnated with bitumenous binder will increase the service life of roads by delaying reflective cracking and providing an impermeable membrane inside the pavement structure. The use and function of a specially designed thermally bonded, non-woven PP geotextile in repairing cracked roads is described.

EUROPEAN COMMUNITY; LUXEMBOURG; WESTERN EUROPE
Accession no.420032

Item 306
High Performance Textiles
Feb.1991,p.6-7
GEOTEXTILES AND ROAD MAKING
The reinforcement attributes and applications of geosynthetics for road construction are outlined by the Indian Institute of Technology particularly for use on unpaved roads in Third World countries. Their use in asphalt overlays is also noted.
INDIAN INSTITUTE OF TECHNOLOGY INDIA
Accession no.419943

Item 307
Plastics and Rubber Weekly
No.1375,2nd March 1991,p.9
EXTRUSION SYSTEM FOR LANDFILL LININGS
Kuhne is reported to have developed an extrusion system for the production of geomembranes, PVC and PE sheeting for landfill sites used for waste disposal; it says that as more useful material is extracted from waste for recycling, the concentration of potentially dangerous contents of remaining waste disposed of will increase. Brief details are noted.
KUHNE GMBH; PROCESS MACHINERY LTD. EUROPEAN COMMUNITY; GERMANY; UK; WESTERN EUROPE
Accession no.419376

Item 308
High Performance Textiles
Dec.1990,p.3-5
HIGH CAPACITY FILTER DRAINAGE
Saval has developed a laminated composite geotextile which is suitable for reinforcing all earthworks and offers high capacity filter drainage. The geotextile is constructed with a series of different but interconnected layers and contains at least two layers with filtering and/or drainage characteristics. The composition of the layers and laminating methods are discussed.
SAVAL SRL EUROPEAN COMMUNITY; ITALY; WESTERN EUROPE
Accession no.415780

Item 309
Plastics News(USA)
NOVA SELLS ITS GEOMEMBRANES PROCESSING UNIT
Lauzon M
The Nova Corp. has sold its geomembrane business, Nova Geotechnical Products Ltd., to a subsidiary of the National Seal Co. When the operation was formed, in 1988, the market was buoyant, with the sheet being used to prevent ground water contamination in waste disposal. Overcapacity has since arisen which has prompted Nova’s move. The joint venture set up with Nylex Corp. to market the membranes has also been dissolved.
NATIONAL SEAL CO.; NOVA CORP.; NOVA GEOTECHNICAL PRODUCTS LTD.; NYLEX CORP.LTD. CANADA; USA
Accession no.415358

Item 310
Rubber World
203,No.2,Nov.1990,p.54
STRESS TESTING GRIP
Curtis ‘Sure-Grip’ has made available the Geo-Grip, which is specially designed for the stress testing of geosynthetics, plastics, rubber and other thin materials. Very brief details are given of the unit, which has the ability to hold specimens up to 8” wide with controlled pressure over the whole width of the sample.
CURTIS SURE-GRIP USA
Accession no.413821

Item 311
Sports Industry
No.82,Dec/Jan.1991,p.10
CHANGING THE FABRIC OF PITCH PREPARATION
A brief account is given of the latest research and development into natural turf cricket pitch maintenance, particularly growing grass through a stiff geotextile pad inserted under a synthetic wicket, and Vhaf Grass Reinforcement for football and rugby pitches.
UK,NATIONAL CRICKET ASSOCIATION EUROPEAN COMMUNITY; UK; WESTERN EUROPE
Accession no.413515

Item 312
LS.45. 10ins. 30/10/89. 63ECi
DURABILITY AND AGEING OF GEOSYNTHETICS
Koerner R M

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DREXEL, UNIVERSITY, GEOSYNTHETIC RESEARCH INST.

This volume contains papers presented at a seminar on ‘Durability and Ageing of Geosynthetics’ held at the Geosynthetic Research Institute in December 1988. Four technical sessions give coverage to geosynthetic concerns and focuses, geotextiles and geogrids, geomembranes, and biological aspects. Consideration is given, in particular, to the durability and long-term performance of geosynthetics in waste containment applications.

EUROPEAN COMMUNITY; UK; WESTERN EUROPE
Accession no.413369

Item 313
Rail Bull.
2, No.4, Autumn 1990, p.6/8
GEOTEXTILES PUT WORLD’S RAILWAYS ON FIRMER FOOTING

PCD (UK) has developed Polyfelt TS, a non-woven, needle-punched endless fibre fabric, for railway applications. This geotextile is being used either as a replacement for gravel sand as a barrier between ballast and subsoil beneath rail tracks, or as a complimentary barrier. Tests have shown that Polyfelt TS performs well as a separation layer and allows the free escape of ground moisture while preventing fine soil particles penetrating the upper protective layer of sand. The fabric also resists the tearing effect of sharp ballast stones.

PCD UK LTD.
EUROPEAN COMMUNITY; UK; WESTERN EUROPE
Accession no.412352

Item 314
Plastics in Building Construction
14, No.12, 1990, p.3
VINYL GEOMEMBRANE PASSES TESTS FOR LINING LANDFILLS

Occidental reports that an independent laboratory has confirmed that its Oxyflex PVC geomembrane material is suitable for landfill applications. Test data showed that all the sheets exceeded the NSF requirements of breaking factor, elongation, modulus, tear resistance and hydrostatic resistance even after 120 days exposure to leachate at 23°C and 50°C.

OCCIDENTAL CHEMICAL CORP.
USA
Accession no.412333

Item 315
High Performance Textiles
Sept. 1990, p.6-7
GEOTEXTILE FILTER AIDS ROADSIDE DRAINAGE

A geotextile drainage system, Secodrain, is designed to keep road surfaces free of water by providing an effective roadside drainage conduit. A trench is dug at the side of the road and lined with a geotextile filter material. A PVC pipe is laid at the bottom of the trench, which is then backfilled with porous concrete. The filter is sealed by the laying machine. The installation procedure and advantages of the system are outlined.

FOURNIER DRAINAGE
EUROPEAN COMMUNITY; FRANCE; WESTERN EUROPE
Accession no.411221

Item 316
High Performance Textiles
Oct. 1990, p.7-8
GEOTEXTILES FOR LAND RECLAMATION

The Eastern Schelde adjustable storm-surge barrier in The Netherlands used woven geotextiles as a major reinforcement. The construction and structure of the barrier are discussed and the geotextiles used are described.

ROBUSTA BV; SULZER BROS. LTD.
EUROPEAN COMMUNITY; NETHERLANDS; SWITZERLAND; WESTERN EUROPE
Accession no.411149

Item 317
Rubber and Plastics News
2, 11, No.24, 10th Sept. 1990, p.2
JPS RESTRUCTURES DIVISION

New products to be produced at JPS Elastomerics’ Environmental Products Div. are briefly described. They are reported to include TerraTuff chlorosulphonated PE synthetic rubber sheet bonded to a textile manufactured from recycled plastic bottles and is used to make caps for landfills or lining areas where the ground is uneven. The Environmental Products Div. was reported to have been restructured from the company’s Containment Membrane Div.

JPS ELASTOMERICS CORP., ENVIRONMENTAL PROD. DIV.
USA
Accession no.409367

Item 318
Blackburn, 1987, pp.3. 12 ins. 2/7/90. 42C11-63ECi-6R41
TENSAR SR80 GEOGRIDS
NETLON LTD.

A product sample and technical details are given for Tensar SR80 geogrids. The product is manufactured from HDPE and is UV stable, chemically resistant, biologically resistant and with a service temperature range from -50°C to +80°C. It is designed for use in soil reinforcing applications, for example in the construction of embankments and retaining walls. Roll dimensions and physical properties are included.

EUROPEAN COMMUNITY; UK; WESTERN EUROPE
Accession no.407831
Item 319
Materie Plastiche ed Elastomeri
No.12,Dec.1989,p.570-5
Italian
INVISIBLE COMFORT
Minarelli T
This review of the Bologna Building Exhibition stresses the use of cellular materials for thermal and acoustic insulation, indicating the environmentally-friendly nature of expanded PS which uses pentane as blowing agent. Attention is drawn to applications of geomembranes in dams, trenches, tunnels and motorways, and of geotextiles on roads and under the sea. The use of expanded polystyrene in roof-garden construction is also described.
ASSOCIAZIONE ITALIANA POLISTIRENE ESPANSO; DEUTSCHER DACHGARTENERVERBAND INT.GEOTEXTILE SOC.; INDUSTRIEVERBAND HARTSCHAUM EUROPEAN COMMUNITY; ITALY; WESTERN EUROPE
Accession no.406829

Item 320
Blackburn, c.1990, pp.3. 12ins. 2/7/90. 42C12-63ECi-6R41
TENSAR SS2 GEOGRIDS
NETLON LTD.
Brief technical details and a product sample are given for Tensar geogrid. It is manufactured from black polypropylene which is ultra-violet stable, chemical resistant and biologically resistant. The geogrid structure has been developed for the stabilisation of weak, low load bearing soils, for example in the construction of temporary and permanent roads. Physical properties and dimensions are included.
EUROPEAN COMMUNITY; UK; WESTERN EUROPE
Accession no.406675

Item 321
Rail Bull.
2,No.3,Summer 1990,p.78-80
GEOTEXTILES PUT WORLD’S RAILWAYS ON FIRMER FOOTING
The use of PCD’s Polyfelt TS, a non-woven, needle punched endless fibre geotextile fabric, for the consolidation of ballast beneath railway tracks is discussed. Experience of its utilisation on Australian, Austrian and German railways is reported.
PCD
EUROPEAN COMMUNITY; UK; WESTERN EUROPE
Accession no.405585

Item 322
Advanced Composites Engineering
5,No.3,June 1990,p.18-20
BRIDGING THE GAP
Holloway L
SURREY,UNIVERSITY
A report is presented on some recent case histories of the use of fibre reinforced plastics in the construction industry. It discusses their use in load bearing applications, usually glass fibre reinforced polyesters; geosynthetic materials (grids, textiles, membranes and composites); and non-corroding reinforcements in concrete including PP, PE, glass and polyester fibres.
EUROPEAN COMMUNITY; UK; WESTERN EUROPE
Accession no.401685

Item 323
High Performance Textiles
July 1990,p.9-10
LINING CANALS WITHOUT INTERRUPTING FLOW
Rebant D B
Special equipment has been developed in the USA to allow canal repairs to be undertaken without draining. The treatment involved travelling along one side of the canal and returning in the opposite direction, laying a PVC geotextile sheet, from a roll, and chemical sealing it with tetrahydrofuran. A specially formulated concrete 76mm thick is then laid on the sheet.
USA
Accession no.401553

Item 324
High Performance Textiles
June 1990,p.6-7
SUPER ABSORBENCY IN AGRICULTURE
The characteristics of superabsorbents in capillary mats for agricultural purposes are briefly described. The superabsorbent is incorporated into a nonwoven fabric to provide a base for root formation and stabilisation of the subsoil. Methods of manufacture and applications are noted.
CHEMISCHE FABRIK STOCKHAUSEN GMBH EUROPEAN COMMUNITY; WEST GERMANY; WESTERN EUROPE
Accession no.400892

Item 325
New Delhi, 1989, pp.iii,16. 11ins. 4/12/89. 42C11-625-63Ag
GUIDELINES FOR USE OF PLASTICS (LDPE FILM) FOR LINING OF CANALS
INDIA, CENTRAL BOARD OF IRRIGATION AND POWER
Discusses the design and techniques of use of LDPE film for lining of canals.
INDIA
Accession no.400035
Item 326

*World Plastics & Rubber Technology*

1990, p. 227-30

**UNDERGROUND WORKERS**

Hunt J A

EXXON CHEMICAL LTD.

A discussion is presented on one of the most significant and fast-growing applications of polymers today, namely geotextiles. Methods of production are briefly outlined, areas of application (separation of soil structures, drainage, erosion control and reinforcement of soil structures) are described and some recent installations are reviewed.

EUROPEAN COMMUNITY; UK; WESTERN EUROPE

*Accession no. 399145*

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Item 327

London, c. 1986, pp. 34. 12 ins. 17/11/86. 43C1-63ECi

**NEW LAYER ON THE EARTH. BIDIM**

MONOMET LTD.; RHONE-POULENC (UK) LTD.

(Also in French). Bidim 100% polyester spunbonded needled non-woven geotextile is described. Its functions and properties are outlined, and its uses in general earthworks, road works, river works, coastal works, water works, drainage and sewerage, protection applications, and parks, gardens and sports grounds are detailed. Brief laying methods are also given. A product sample is included and technical characteristics and properties are tabulated.

EUROPEAN COMMUNITY; UK; WESTERN EUROPE

*Accession no. 399144*

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Item 328

*Chemical and Engineering News*


**ADVANCES MADE IN WAYS TO STABILISE GEOTEXTILES**

Haggin J

Geotextiles are being used increasingly as a substitute for sand and gravel, in heavy duty ground applications, such as containment ponds. Polyolefins, mainly polypropylene, are the most frequent choice for geotextiles, but in these applications a greater degree of stability is needed. Thermal stabilisation is achieved by incorporating a radical terminating antioxidant. Ultraviolet stabilisation can be achieved in one of three ways: by screening and heat dissipation; by molecule ‘quenching’; and the use of hindered amine light stabilisers.

CIBA-GEIGY CORP.

USA

*Accession no. 399055*

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Item 329

St. Albans, c. 1989, pp. 2. 12 ins. 10/5/89. 42C11-6P253

**MONARFLEX R.A.C. MEMBRANE**

MONARFLEX LTD.

Monarflex R.A.C. membrane has been specially developed for use as a tanking membrane for protection against hydrocarbons and other volatile pollutants. It consists of a 9 micron aluminium foil bonded onto Monarflex 500 geomembranes. The foil is coated with a layer of 0.2mm polyethylene film to give physical protection during installation. A sample of the material is included, and its properties and chemical resistance are described.

UK; WESTERN EUROPE

*Accession no. 397535*

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Item 330

Linz, 1988, pp. 8. 12 ins. 11/10/89. 42C12-62(14)-6R1

**POLYFELT GEOTEXTILES. THE GEOTECHNICAL SOLUTION**

POLYFELT GMBH

Technical product data and illustrated examples of applications are given for Polyfelt geotextiles for use in civil engineering and building construction applications. Examples cited include road construction, embankment construction, drainage, retaining walls and geomembrane protection, where they fulfil a number of functions such as separation, filtration, protection and reinforcement. Advantages of its use are described and features of Polyfelt are briefly listed. These include needle-punched filaments, use of continuous filaments, and use of UV stabilised PP.

AUSTRIA; WESTERN EUROPE

*Accession no. 397494*

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Item 331

Linz, 1988, pp. 4. 12 ins. 11/10/89. 42C12-62(14)-6R1

**POLYFELT PGM 14 PAVING FELT UNDERLINES PAVEMENT PERFORMANCE**

POLYFELT GMBH

A description is given of Polyfelt PGM 14 paving felt, designed to improve the long term integrity of bituminous road surfacing. It is manufactured from continuous filaments of polypropylene into a strong flexible three dimensional structure. Adhesion of surfacing layers is improved, interface stresses relieved, reflective cracking is retarded, and moisture and oxygen penetration is prevented. Areas of application and installation methods are described, and properties are tabulated.

AUSTRIA; WESTERN EUROPE

*Accession no. 397493*

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Item 332

*Journal of Coated Fabrics*

10, Oct. 1989, p. 129-31

**CIVIL ENGINEERING APPLICATIONS FOR COATED FABRICS**

Marienfield M L

PHILLIPS FIBERS CORP.

Each of the major civil engineering coated fabric products and their end uses are outlined, with particular emphasis...
on coated geotextiles. Geotextiles as paving fabrics and soil separation/stabilisation materials are included, together with geomembranes for roofing products.

USA
Accession no.394761

Item 333
Plastics in Building Construction
13,No.9,1989,p.9-10
USE OF GEOMEMBRANES/GEOTEXTILES GROWS IN CIVIL ENGINEERING PROJECTS

Brief extracts are presented from a 236-page study entitled Geosynthetics Market in the US published by Frost & Sullivan Inc. The market study includes analysis of the geosynthetics marketing and distribution process and the roles of such key players as consulting engineers. Important companies are profiled individually and their competitive strategies examined.

FROST & SULLIVAN INC.
USA
Accession no.390429

Item 334
High Performance Textiles
8,No.12,June 1988,p.10-1
NON-WOVENS IN GEOTEXTILES

A brief report of the US Industrial Fabrics Association convention in Las Vegas is given. Growth of geotextiles has increased at the rate of 8-10% since 1983 and by 20% from 1986/87. Consumption of geotextiles since 1983 has risen from 150 million sq.yds. to 240 million sq.yds (1986). It is predicted to increase to 370 million sq.yds. by 1990. Other information is mentioned in a brief article.

USA
Accession no.389802

Item 335
High Performance Textiles
10,No.4,Oct.1989,p.9-10
GEOTEXTILE REINFORCES SWISS RIVER BANK

The reinforcement of a Swiss river bank by use of a hybrid material comprising PP and ramie (a natural flax-like fibre) is described. The requirements imposed on the geotextiles are discussed and the Terranet fabric selected for the project is considered.

BAECHTOLD AG; SCHWEIZER GESELLSCHAFT FUER TUELLINDUSTRIE AG
SWITZERLAND
Accession no.389145

Item 336
High Performance Textiles

COMPOSITE GEOTEXTILE

Geotextile and filtration applications are cited for Unitika Bonded Mat ‘UBM 600’ a woven/non-woven polyester fabric composite from Unitika Ltd. A polyester binder fibre, Melty, is reported to be used in the construction of the fabric to consolidate it.

UNITIKA LTD.,INDUSTRIAL FIBRES & FABRICS DIV.
JAPAN
Accession no.389051

Item 337
Sarnia,Ont., 1984, pp.5. 11ins. 9/6/87. 63ECi
LONGEVITY ASPECTS OF POLYMERIC LININGS FOR WATER CONTAINMENT
Strong A G
POLYSAR LTD.

The nature and effect of stress as a direct influence on the longevity of polymeric linings for water containment are examined. The ability of a geo-membrane to bridge a gap created by ground movement with minimum property loss is a major contribution towards the expected longevity. The behaviour of membranes under such conditions is studied, and the value of thickness and the role of textiles is emphasised. The importance of high strength and elongation is inferred and tests more specific to membrane service are discussed. These include the effect of stress measured at site temperature after ageing in the unstressed and strained states. 8 refs.

CANADA
Accession no.387440

Item 338
Slough, 1987, pp.10. 12ins. 13/11/88. 43D1-6272
REHAU ARMAPAL GEOGRID REINFORCEMENT FOR PAVEMENTS
REHAU PLASTICS LTD.

Rehau Armapal is a range of geogrids made from high modulus polyester yarn, designed for use in construction, reconstruction, repair or strengthening by overlay of pavements using bituminous materials. It is available as a glass fibre version (Rehau Armapal G) offering higher modulus properties. Applications and installation methods are described and technical data are included. A product sample of Rehau-Armapal 6030 is included.

UK; EUROPEAN COMMUNITY
Accession no.387439

Item 339
Altrincham, c.1987, pp.4. 12ins. 20/11/89. 42C12-62(14)-63ECi
AMOPAVE ASPHALT OVERLAY ENGINEERING FABRIC. TECHNICAL MANUAL
AMOCO FABRICS CO.
A product sample and a technical description are presented for Amopave, an asphalt overlay fabric for pavement repairs. Amopave is a needle punched polypropylene design which readily absorbs tack coat to form a strong permanent bond between new and old layers of asphalt. Details are given of installation methods, properties and product specifications.

UK
Accession no.386566

Item 340
Construction & Building Materials
3,No.2,June 1989,p.78-80
GEOFABRICS IMPROVE LOAD BEARING CHARACTERISTICS OF FLYASH
Murtaza G;Shah S S;Ahmad M
ALIGARH,UNIVERSITY

The use of flyash in earthworks reinforced with geofabrics, to improve the load bearing characteristics is discussed. The composition of the flyash studied, obtained from thermal power plants in India, is detailed and Madura Coats (type 3C) geofabric is used in the tests. Different laboratory tests, including California Bearing Ratio and Triaxial tests are conducted to compare the behaviour of load bearing characteristics. 7 refs.

INDIA
Accession no.386493

Item 341
Plastics News(USA)
1,No.19,10th July 1989,p.11
MICHIGAN REGULATES ASH DISPOSAL

Michigan’s solid waste regulations now govern the generation, transportation, treatment, storage and disposal of municipal solid waste incinerator ash. The ash may be deposited in specially designed pits or monofills located in solid waste landfills but kept separate from general garbage. The law includes an option for 3 layer liners in landfills consisting of a leachate collecting system under the ash, a synthetic liner of at least 60mm thick, a geotextile layer of at least 100mm thick, a synthetic liner of at least 40mm thick, a geotextile layer of at least 100mm thick, a leak detection and leachate collection system, and a synthetic liner of at least 40mm thick.

USA
Accession no.386291

Item 342
Kunststoffe Plastics
36,No.2,Feb.1989,p.29
German
FABRICS:MEASUREMENTS AND CONTROL OF INHOMOGENEOUS PRODUCTS

A description is given of the FH 46M system from FAG Kugelfischer suitable for the measurement and control of weight per unit area of geotextiles made from plastics fibres.

FAG KUGELFISCHER
WEST GERMANY
Accession no.385944

Item 343
Deformation,Yield and Fracture of Polymers.Proceedings of the 7th International Conference.
Cambridge,11-14 April 1988,p.64/1-64/5. 951
DEFORMATION OF THICK SECTION POLYPROPYLENES AT HIGH STRAIN RATES, FOR ORIENTED GEORGIDS
Coates P D;Ellis D I;Pourmahnaei S M;Martin K
BRADFORD,UNIVERSITY; NETLON LTD. (PRI)

Preliminary results are presented of studies of the significant effects of specimen geometry and forced convective heat transfer on the magnitude and distribution of temp. rise in thick PP and PE samples drawn uniaxially at high strain rates. The studies are part of a wider investigation related to the commercial Tensar process for the manufacture of geogrids. 3 refs.

UK
Accession no.384903

Item 344
New Materials/Japan
6,No.9,Sept.1989,p.14
COMPOSITE GEOTEXTILE

A composite of woven and non-woven polyester fabric called ‘Unitika Bonded Mat UBM 600’ is being produced by Unitika Ltd. The material incorporates a polyester binder fibre known as ‘Melty’ which consolidates the construction. Its water permeability characteristics make it particularly suitable for applications such as geotextiles or filter media.

UNITIKA LTD.
JAPAN
Accession no.384742

Item 345
Plastics in Building Construction
13,No.5,1989,p.4
NYLON ‘ENKAMAT’ HELPS SOLVE EROSION PROBLEMS

Enkamat is a lightweight, flexible alternative to concrete, asphalt and rip-rap systems for controlling soil erosion. It is a 3 dimensional matrix of heavy nylon monofilaments fused at their intersections. Applications in the USA are described in a brief article.

USA
Accession no.383057
The use of paving felt to reduce reflective cracking of roads is briefly discussed. Examples of the use of Polyfelt PGM 14, such as on the hard shoulder of the M20 in Kent, are given.

**UK; USA**

**Item 347**
**Constr.Wkly.**
16th Aug.1989,p.16
**SYNTHETICS FOR EARTH BUNDS**
Petri A
MMG CIVIL ENGINEERING SYSTEMS

MMG Civil Engineering Systems’ use of a polyester geogrid, Akzo’s Fortrac, in the construction of a reinforced soil wall in Kent, is briefly described.

AKZO CHEMIE BV; MMG CIVIL ENGINEERING SYSTEMS

**UK**

**Accession no.382999**

**Item 348**
**Constr.Wkly.**
16th Aug.1989,p.14/6
**GEOMEMBRANES FOR LANDFILL**
Boyes R

The use of geomembranes and geotextiles in waste disposal is discussed. The need for proper inspection and supervision of installation is stressed since inadequate supervision, rather than the wrong selection of polymer type and grade is said to have been the main reason for failures. Two geofabrics mentioned are Monarflex RAC membrane and Rawmat.

**UK**

**Accession no.382998**

**Item 349**
**Constr.Wkly.**
**GEOSYNTHETICS INDUSTRY TAKES OFF**
Ingold T

A brief review of recent developments in the geosynthetic industry is presented. Market leaders such as Exxon Chemicals’ Terram range of non-woven geotextiles; Don & Low’s Lotrak range of woven fabrics; and Netlon’s Tensar geogrid and Netlon geomesh range are mentioned. Particular reference is made to the application of geosynthetics in soil reinforcement and toxic waste control. 2 refs.
compounds in the nodules can release chemicals into the ground on a gradual or long-term basis. Suggestions are made for the slow release system, dispersed in a watersoluble polymer.

USA
Accession no.380594

Item 353
High Performance Textiles
9, No.8, Feb. 1989, p.5
ECONOMICAL GEOTEXTILES

Brief details are provided on the use of PP Mirafi 1000 HP in the construction of a new sea wall, at Harris Harbour Alaska, which was built at a cost of only 1.86 US dollars/sq.m. compared with 4.65 US dollars for "a soldier pile bulkhead and a reinforced earth wall".

USA
Accession no.379935

Item 354
Modern Plastics International
19, No.4, April 1989, p.54-6
GEOSYNTHETICS PROVE TO BE VITAL ORGANS IN SANITARY LANDFILL
Leaversuch R D

The role of plastics as geosynthetics in landfills are discussed in detail. Information is given on geomembranes, cap liners, drainage mediums and geotextile erosion mats made from materials such as HDPE and PVC. Other factors in the construction of landfills discussed include containment of environmental hazards and space saving methods.

GEOSERVICES INC.
USA
Accession no.378990

Item 355
High Performance Textiles
9, No.7, Jan. 1989, p.8-10
WEST GERMAN GEOGRIDS USED IN ROAD CONSTRUCTION

Rehau’s Armapal range of geogrids, some of which are based on a reinforcement of high tenacity polyester yarns, is described. The physical properties of the geogrids are tabulated and their use in construction of various types of road surfaces is discussed.

REHAU PLASTICS AG
WEST GERMANY
Accession no.378987

Item 356
St. Albans, c. 1989, pp. 4. 12ins. 10/5/89. 62(11)-63ECi-6L2
MONARFLEX GEOMEMBRANE LINING

USA
Accession no.378994

SYSTEM
MONARFLEX LTD.

The geomembrane lining system from Monarflex is described, and a sample of the material is included. It consists of a non-laminated low density polyethylene with a non-woven polyester scrim reinforcement. The material is available in factory welded sections up to 1500 sq.m., and can be further joined by continuous extrusion welding on site. Monarflex 500 geomembrane lining system can be used on landfill sites, in sewage works, for sealing reservoir roofs and for the construction of ornamental water features. These applications are illustrated and physical properties are listed for the product.

UK
Accession no.378383

Item 357
High Performance Textiles
9, No.9, March 1989, p.10-1
GEOTEXTILES FOR ALL APPLICATIONS

Enka Industrial Systems range of geotextiles is reported to be marketed by MMG Civil Engineering Systems in the UK. Brief details are presented on each of the products which include Enkamat nylon matting for erosion control, Enkazon pre-grown turf incorporating Enkamat, Stabilenka woven polyester fabric for retaining structures such as stabilising embankments, Colbonndrain non-woven polyester material with a three-dimensional thick polyester monofil open core for anti-clogging drainage, Enkadrain nylon and polyester non-clogging drain material, and Armater non-woven polyester fabric strips linked to form a honeycomb structure material for elimination of land sliding and gulleying.

ENKA BV; MMG CIVIL ENGINEERING SYSTEMS NETHERLANDS; UK
Accession no.377524

Item 358
High Performance Textiles
9, No. 9, March 1989, p.9-10
TEXTILES USED IN DRAINS

A fairly brief description is given of a new drainage material from BTR Industries. BTR Landscaper consists of a geotextile Terram filter fabric of spunbonded PP with a PS core which allows the water to be filtered through the fabric and drain through the core preventing clogging by soil particles.

BTR INDUSTRIES PLC
UK
Accession no.377523

Item 359
Textile Horizons
9, No. 2, Feb. 1989, p.28-31
NEW GEOTEXTILE FROM SYNTHETIC AND NATURAL FIBRES
Stadler R

The use of a geotextile fabric, made from yarns of both synthetic (PP) and natural (ramie) fibres, in the reconstruction of a river bank in Switzerland is reported. The particular features of the Terranet Type 50226 from the Swiss Net Company Ltd. (Tullindustrie AG) are outlined and the integration of the geotextile into the bank is described.

SWISS NET CO.LTD.; TULLINDUSTRIE AG
SWITZERLAND; UK
Accession no.377442

Item 360
Textile Horizons
9, No.2, Feb. 1989, p. 24-7
DURABILITY OF GEOTEXTILES
D’Souza J; Horrocks R
BOLTON, INSTITUTE OF HIGHER EDUCATION

The durability of geotextiles for use in civil engineering constructions is discussed with reference to the principal degrading agencies and related accelerated ageing procedures. The ageing behaviour of different fibre types is examined with details given on HDPE, PP, PETP, nylon and aramid fibres. Methods of effective lifetime prediction are outlined. 1 ref.

UK
Accession no.377440

Item 361
Modern Plastics
66, No.4, April 1989, p.149
NYLON/POLYESTER MATTING HELPS PREVENT BUILDUP OF RADON IN HOMES
Lindsay K F

Akzo has developed this control matting which consists of a non-woven polyester geotextile filter fabric heat-bonded to durable and resilient nylon monofilaments. The installation of Enkavent, which measures 0.8 in. thick and contains about 90% airspace, is briefly described.

AKZO INDUSTRIAL SYSTEMS
USA
Accession no.376698

Item 362
High Performance Textiles
9, No.5, Nov. 1988, p.10-1
PERMAFROST ROAD USES GEOTEXTILES

A road across a permafrost region in Alaska has been constructed using geotextiles; it has been designed to withstand very heavy loads up to 1800 tonnes. Design considerations to be tackled are outlined and the final construction is described briefly. The fabric selected was Nicolon 64109 woven PP developed specially for this task.

USA
Accession no.372784

Item 363
Chemistry & Industry
No.13, 4th July 1988, p.414-20
PLASTICS IN THE GROUND. PERFORMANCE OF POLYMERIC MATERIALS
Wrigley N
NETLON LTD.

The performance of polymeric materials, chiefly PP, PE and PET, used in combination with bulk civil engineering materials in geotechnical applications is discussed. Aspects considered are compatibility and interaction with the fill material, tensile strength under sustained or dynamic loads, resistance to site damage, transmissivity through plane or in-plane, compression strength, chemical and biological resistance, resistance to UV light, and the effects of ageing. Data for Tensar geogrids are among those included. (Meeting of the Road & Building Materials Preservation Groups of the SCI, London, 17th March 1988). 24 refs.

UK
Accession no.371967

Item 364
STABILISATION OF PP FIBRES AND TAPES FOR TEXTILE AND GEO-TEXTILE APPLICATIONS
Root S; Stengrevics E
CIBA-GEIGY CORP.
(SPE, South Texas Section; SPE, Thermoplastic Materials & Foams Div.)

The manufacture, storage and end-use exposure, both UV and thermal, of PP fibres and tapes are explored. The superior performance of HALS-1 and HALS-2 (hindered amine light stabilisers) in controlling both light and thermal degradation is demonstrated. The use of the correct antioxidant and phosphite to produce products stable enough for carpet and geotextile applications is explained.

USA
Accession no.371886

Item 365
Poliplastici e Plastici Rinforzati
36, No.368/9, July/Aug. 1988, p.54-6
Italian
WORLD’S LARGEST 3-PLY SHEETING

HDPE 943 C is a geomembrane 11.2m wide. It is formed by coextrusion of a centre layer of carbon-filled PE sandwiched between layers of a different type of PE. The outer layers, of medium density PE, may be of Eraclear
References and Abstracts

35 B, Eraclear 51-35 BO or Eracle H AB 5015, products designed and produced by EniChem ANIC for this particular application. Greater width laminate could be produced by the technology used by the extruder (La Caleppio ILT), but transport restrictions impose the above limit. The width actually produced reduces the amount of welding required, and the quality of the product ensures durable welds when made by highly expert operators. Price: 9800 lire/sq.m. (2mm thick).

ENICHEM ANIC SPA; LA CALEPPIO ILT
ITALY
Accession no.371096

Item 366
Plastics and Rubber Asia
3,No.16,June 1988,p.44-5
PLASTICS MESH GOES RACING - AND IT’S A WINDER!
The use of Netlon mesh elements as a turf reinforcement for the Happy Valley racecourse in Hong Kong is outlined. Use of a parallel range of products, produced by the Tensar division of Netlon, for embankment foundations, road stabilisation and surface erosion prevention schemes in Japan, Hong Kong and Malaysia is also briefly noted.

NETLON LTD.; TENSA CORP.
HONG KONG; JAPAN; MALAYSIA; UK; USA
Accession no.370418

Item 367
Modern Plastics International
19,No.1,Jan.1989,p.4
MASTERBATCH OFFERS HIGH UV PROTECTION
A masterbatch of very fine highly dispersed particles of furnace black in HDPE provides long term protection against ultraviolet radiation in HDPE geogrids used to reinforce engineering structures. The masterbatch is made by Cabot Plastics Europe and is being used by Netlon in its Tensar grids for the construction of embankments and retaining walls.

CABOT PLASTICS EUROPE; NETLON LTD.
UK; WESTERN EUROPE-GENERAL; WESTERN EUROPE
Accession no.370327

Item 368
Plastics in Building Construction
11,No.12,1988,p.2-3
GEOTEXTILE AGGREGATE TAKES PLACE OF CONCRETE EMBANKMENTS
Brief details are provided on a new type of geotextile aggregate, which can be used as a three-dimensional reinforcement material that is cohesive enough to take the place of concrete embankments. The aggregate, called Texsol, is made by weaving continuous polyester, polyamide, PE or PP fibres into soil mixtures at the construction site. Other uses of Texsol available from Societe d’Application du Texsol, are indicated.

SOCIETE D APPLICATION DU TEXSOL
FRANCE
Accession no.367015

Item 369
Polypropylene Fibres and Textiles.Proceedings of the 4th International Conference.
BEHAVIOUR OF PP POLYESTER GEOTEXTILES AS SEPARATING MEMBRANES
Glynn D T;Cochrane S R;Uprichard J E
QUEEN’S UNIVERSITY OF BELFAST (PRI)
The development of a method for evaluating the ability of geotextile fabrics used in road construction to minimise the migration of fine clay particles from the clay below to the road stone layer above is described. The mechanisms by which these fine clay particles are transferred or ‘pumped’ upwards through the fabric to contaminate the stone layers are also examined. Four different constructions of geotextile fabric, i.e. plain woven monofilament tapes of PP (Scott-lay) , melt-bonded continuous filament fibres of PE and PP (Terram), needle-continuous polyester filaments (Bidim) and a PP composite (Lotrak). 9 refs.

UK
Accession no.365751

Item 370
Polypropylene Fibres and Textiles.Proceedings of the 4th International Conference.
ASSESSMENT OF PP FABRIC FOR GEOTEXTILE APPLICATIONS
Ramawamy S D;Nathor M N
SINGAPORE,NATIONAL UNIVERSITY (PRI)
Areas where PP fabrics find potential applications as geotextiles in civil engineering projects are indicated and examples of projects, which have successfully made use of PP fabrics, are cited. Relative endurance properties, UV stability and selection of types for durability of PP fabrics are discussed as is the use of PP fabrics in tunnel construction. The overlapping and laying of PP fabrics under water is also dealt with and an assessment made of long-term performance, based on published data. 12 refs.

SINGAPORE
Accession no.365749
Item 371
Polypropylene Fibres and Textiles. Proceedings of the 4th International Conference.
STRESS AND STRAIN EVALUATION IN SPUNBONDED AND NEEDLE PUNCHED GEOTEXTILES UNDER LOAD
Rigo J M
LIEGE, UNIVERSITY (PRI)
A theoretical approach for calculating stresses and strains in thermobonded and spunbonded non-woven geotextiles under load is proposed. Using this theory, lateral contractions observed during tensile testing with different widths can be explained. 7 refs.
BELGIUM
Accession no.365748

Item 372
Polypropylene Fibres and Textiles. Proceedings of the 4th International Conference.
PROPERTIES OF PP-MESH REINFORCED CEMENT COMPOSITES
Kenai S; Brooks J J; Dalton D C
LEEDS, UNIVERSITY (PRI)
The tensile properties of a geotextile mesh are described together with the method of manufacture of the composite (Lotrak 22/16). Composite properties, such as flexural strength and impact strength, are reported and discussed and the effect of mesh content thereon evaluated. To assess the properties of the composite in general practice, structural stability under three different curing environments were investigated, namely 20°C in a fog room, 35°C in an environmental chamber at 70% R.H. and 65°C in water. 4 refs.
UK
Accession no.365739

Item 373
High Performance Textiles
9, No.1, July 1988, p.10-2
SPUNBONDED FLAT FILAMENT PREVENTS ROAD CRACKS
A geotextile (GB 2185500) to be interposed between the base and surface layers of roadways and pavements to prevent the surface layer cracking, is briefly described. Developed by Jacques Perfetti of Rhone-Poulenc Fibres, the interface consists of a bitumen-impregnated, spunbonded nonwoven fabric made from polyester filaments of flat cross section. Trials are reported which show the superior results obtained by use of the above geotextile compared with a conventional, compressible spunbonded nonwoven with circular cross-section filaments.
RHONE-POULENC FIBRES
FRANCE
Accession no.364114

Item 374
European Plastics News
15, No.9, Sept. 1988, p.50
GEOMEMBRANE SHEET CAN BE UP TO 5M WIDE
Satellite Extrusions is producing geomembrane sheet up to 5m wide in gauges from 1.0 to 3.0mm, in HDPE, LLDPE, ultra low LDPE and rubber modified forms. The wide sheet is produced by a combination of sheet extrusion and extrusion welding. This technique is said to give much better gauge control than alternative methods and provides for pressure testing of welds on site. The sheet route also allows much greater choice of raw materials and, hence, of specifications. The Absat sheet has been used for canal liners, landfill sites and amenity lakes. This abstract includes all the information contained in the original article.
SATELLITE EXTRUSIONS LTD.
UK
Accession no.363870

Item 375
High Performance Plastics
5, No.9, July 1988, p.1-5
NETLON AND TENSAR MESHES AND GEOGRIDS
Collyer A A
One of the commonly-employed techniques for increasing the modulus and tensile strengths of engineering thermoplastics is said to involve the redesign of the molecular architecture, so that polymer chains are less free to move. This involves the synthesis of new and more sophisticated materials; a simpler and less expensive method is to design the polymer chains of ‘commonplace’ materials such as PE, PP and PETP by orientation. Details are given of the manufacture of Netlon and Tensar oriented products, which are used in civil engineering applications. 2 refs.
NETLON LTD.
UK
Accession no.360399

Item 376
Civil Engineering (London)
March 1988, p.52/5
GEOTEXTILES IN SLOPE PROTECTION AND EROSION CONTROL
Barker D H
LAND CONSERVATION ASSOCIATES
Slope protection and erosion control are discussed with particular reference to the use of geotextiles. Available surface-laid geotextiles such as the polymer meshes Netlon CE131 and Broplene Landmesh, and surface-buried geotextiles such as the 3-dimensional, random matrices Enkamat and Geoweb are listed and their roles are considered. 2 refs.

UK
Accession no.358867

Item 377
Civil Engineering (London)
May 1988, Airport Construction ’88 Supplement, p.11
GEOTEXTILE SPEEDS TAXIW AY CONSTRUCTION

Cementation Construction has used a needle-punched non-woven Metlon 514R geotextile as a horizontal drainage layer at Stansted Airport. Up to 3 layers have been used to speed up the consolidation of the clay. Technical details of the textile are given.

BRITISH AIRPORTS SERVICES LTD.; NAUE FASERTECHNIK; NETLON LTD.
UK; WEST GERMANY
Accession no.358846

Item 378
High Performance Textiles
8, No.11, May 1988, p.8-9
GROUND STABILISATION

Considerable effort is reported to have been expended in the geotextiles field on the creation of geogrids. These are laid in place on the ground and covered with various materials, while providing what is essentially a skeletal support. Comporgan Rendszerhaz KV of Budapest has developed a new ‘surficial’ structure, intended for the protection of earthworks, dams, embankments, side slopes, waste rock piles, slope walls of fly-ash bunkers, grids for mountain entrapment, reinforcement and binding of river beds and brooks and for making coating of dykes and numerous other uses such as binding arable soils which may otherwise be liable to erosion. Details are given.

COMPORGAN RENDSZERHAZ KV
HUNGARY
Accession no.358200

Item 379
Oilman
April 1988, p.30
SCOUR CONTROL MAT FOR PREVENTING LOCAL EROSION NEAR SUBSEA STRUCTURES AND PIPELINES

The system, called SSCS Scour Control Mat, from Seabed Scour Control Systems, is based on lines of buoyant PP fronds forming a viscous drag barrier. These fronds form a mat held on the seabed by anchors hydraulically driven to 1 metre.

SEABED SCOUR CONTROL SYSTEMS
UK
Accession no.355584

Item 380
Plastics and Rubber Weekly
No.1231, 2nd April 1988, p.3
ERA STUDY FOCUSES ON GEOTEXTILES UNDER LOAD

ERA Technology is undertaking a three-year project covering the long term properties of geotextiles under load, which will pay particular attention to the effects of holes, tears and other damage that can occur when the materials are first installed on site. The company has the support of the Department of Trade & Industry and most of the major UK companies involved in geotextiles; brief details are noted.

ERA TECHNOLOGY LTD.; UK, DEPT. OF TRADE & IND.
UK
Accession no.354901

Item 381
High Performance Textiles
8, No.8, Feb. 1988, p.12
SOVIETS USE GEOTEXTILES IN ROADS AND BANKS

In the Soviet Union, nylon waste from synthetic fibre plants is collected, melted, granulated, screw extruded and needle punched to produce a fabric used in motorway construction, as geotextiles and road construction in permafrost areas.

USSR
Accession no.354098

Item 382
High Performance Textiles
8, No.8, Feb. 1988, p.10-2
GEOTEXTILES IN SOIL

A brief outline is presented of the results of work carried out on the water permeability of soil-geotextile systems by the US, Dept. of Agriculture and the University of Tennessee. Tests were carried out using a specially designed laboratory-type permeator to determine liquid flow behaviour through various combinations of soils and geotextiles subjected to different flow rates and hydrostatic pressures. The geotextiles evaluated were spunbonded fabrics made from polyester (Trevira S and Stabilena) and PP (Supac N).

TENNESSEE, UNIVERSITY; US, DEPT. OF AGRICULTURE
USA
Accession no.354012
AN IMPORTANT MARKET
Lennox-Kerr P

Some recent applications of geotextiles are described. These include the use of an 80% PP/20% polyester woven material from Akzo in land stabilisation, Kuraray Co.'s development of a simple, low cost woven construction that offers plants protection from heavy rain and yet retains maximum air- and moisture-permeability, and a variety of developments in the construction of drain envelopes. 3 refs.

AKZO CHEMIE NV; KURARAY CO.LTD. UK
Accession no.353262

APPLICATION AND MANUFACTURE OF WOVEN GEOTEXTILES
Achermann A

Details are given of three specific applications of woven geotextiles: in the construction of a shopping centre at Rennaz, a railway siding at Dottikon and a drainage system near Saint Pierre du Vauvray. Fabric specifications of the PP/polyester, polyester and PP geotextiles used are provided. The manufacture of woven geotextiles is discussed with particular reference to the advantages of projectile-weaving machines.

UK
Accession no.353260

REMAKING THE LANDSCAPE
Minarelli T

The function and uses of geotextiles are outlined. Woven and non-woven fabrics are considered, their role in promoting cohesion and drainage being emphasised. The use of the above materials in conjunction with plastics, elastomers or bitumen to produce impermeable geomembranes to act as barriers against possible environmental contaminants is also discussed. One typical use is a combination of non-woven continuous polyester filaments and bitumen as a road surfacing material to combat cracking under stress from traffic. (Saie 87, Bologna).

ASSOCIAZIONE GEOTECNICA ITALIANA; BOLOGNA, UNIVERSITA; LANDOLT; RILEM ITALY
Accession no.353047

GEOTEXTILE REPLACES CONCRETE EMBANKMENT

Brief details are provided on a geotextile aggregate, called Texsol, made by Societe d'Application du Texsol. The aggregate is produced by weaving a continuous web of synthetic textile fibres (polyester, polyamide, PE or PP) into a load of sand or building soil and may be used as a three-dimensional reinforcement material that is cohesive enough replace concrete embankments. It is strong, flexible and permeable and capable of absorbing shocks caused by earthquakes and vibration.

SOCIETE D APPLICATION DU TEXSOL FRANCE
Accession no.351557

HDPE BAFFLES FOR MATURATION PONDS
Aquatan has been contracted to supply HDPE baffles for maturation ponds at the Kabokweni sewerage works in KaNgwane, near Nelspruit. The baffles, which provide a cost-effective alternative to concrete, are like curtains, trapezoidal in shape, and are anchored into trenches backfilled with river sand and stone on the floor and sides of the ponds. This abstract includes all the information contained in the original article.

AQUATAN PRODUCTS PTY.LTD. SOUTH AFRICA
Accession no.342512

DESPITE CHANGES, PROBLEMS, UNDERGROUND MEMBRANE LINER FIELD STILL HOLDS PROMISE

The present state of the US underground membrane liner market is discussed in detail. Carlisle Corp.'s SynTec System Division left the scene in August 1985, the move blamed on rising liability insurance rates, environmental regulations are reported to be becoming tougher and newer, more competitive materials are entering the field.

BURKE INDUSTRIES INC.; CARLISLE CORP., SYNTEC SYSTEMS DIV.; GOODRICH B.F., CO. USA
Accession no.281014
Item 389
Dundee, 1984, pp.64. 12ins. 14/8/85. 63ECi
GEOTEXTILES DESIGN GUIDE
DON & LOW PLC

This design guide on the use of permeable synthetic membranes is drawn from the published data and from experience relating to geotextiles. It is aimed at practising engineers and attempts to follow a logical sequence of design. Major areas of interest are use of geotextiles in paved and unpaved roads, drainage, erosion control, soil reinforcement, embankments, walls, slope remedial works and soil reinforcement. 26 refs.

TENSAR CORP.
UK
Accession no.277726

Item 390
Plastics and Rubber Weekly
No.1104,7th Sept.1985,p.14
DOING THE GROUNDWORK FOR LONG TERM TEXTILES

The long-term durability and strength of geotextiles is becoming increasingly important as these materials gain increased usage in a variety of load-bearing applications. The Battelle Institute is now launching a long term study for the testing of geotextiles. Brief details are provided.

BATTLE INSTITUTE
USA
Accession no.280925

Item 391
Civil Engineering (London)
July 1985,p.22/7
GEOTEXTILES - APPLICATION AND USE

Areas of application for geotextiles and geomembranes are presented with detailed case studies for each civil engineering project. Polyester woven fabric soil stabilisers; Geoseal PP/PE laminate membrane water tank liner; floating Hypalon covers for potable water; capillary membrane for control of salt and moisture migration, reinforcement of bridge approach road embankment and river closure in Bangladesh, are the applications detailed.

UK
Accession no.278511

Item 392
Plastics and Rubber International
10,No.4,Aug.1985,p.20-4
RAPID ADVANCE OF HIGH STRENGTH POLYMER GRIDS IN CIVIL ENGINEERING APPLICATIONS
Templeman J
NETLON LTD.

The Tensar process was invented in 1978 specifically to produce a soil reinforcement not subject to corrosion.

Tensar grids have been rapidly introduced into a wide variety of civil engineering applications. Production and development of the grids is described, together with their use in applications including soil retaining walls, flood walls, motorway repairs, road construction, cellular reinforcement, pavement reinforcement and building applications. 19 refs.

TENSAR CORP.
UK
Accession no.269865

Item 393
Civil Engineering (London)
May 1985,p.30/48
GEOTEXTILES - DEVELOPMENT, RESEARCH AND DESIGN

A review is presented of polymeric geotextiles used in civil engineering applications such as earthworks reinforcement, erosion stabilisers and as a drainage medium. Geotextiles are manufactured from polyamides, PP or polyester using a range of techniques which are divided into wovens and non-wovens. Details are given of design guides and standards, testing, and research and development. 2 refs.

UK
Accession no.273690

Item 394
Plastics and Rubber Weekly
No.1084,20th April 1985,p.15
SHARP FIN BREAKS WATER

Brief details are given of BTR’s new Hitek Fin Drain system for subsoil drainage. It is available in two types; Stripdrain for groundwater interception and lowering applications, and Cordrain for vertical applications; and it consists of a deep dimpled plastic core surrounded by a textile filter fabric.

BTR LTD.
UK
Accession no.272110

Item 395
Chemsphere Americas
Fall/Winter 1984/85,p.19-22
UNDERGROUND STORY

Details are given of the use of geotextile fabrics, manufactured by Exxon Chemical Americas, whose role is to stabilise and prevent soil erosion. The geotextiles are made of oriented PP slit film.

EXXON CHEMICAL AMERICAS INC.
USA
Accession no.269865
TENSAR AND NETLON GEOGRIDS FOR SLOPE STABILISATION AND ROCK FACE PROTECTION NETLON LTD.

Tensar Geogrids are manufactured from high strength polymer structures produced by the above company. The polymers are such that the long chain molecules are oriented into one direction so as to increase the tensile strength. The grids are therefore particularly suitable for soil stabilisation. 5 refs.

UK
Accession no.268064

SOIL STABILISATION WITH TENSAR GEOGRIDS: THE DESIGN INCLUSION OF POLYMER GRIDS INTO FOUNDATIONS AND PAVEMENT STRUCTURES NETLON LTD.

Tensar Geogrids are high strength polymer structures manufactured using a technique which orientates the long chain molecules within the polymer. The grids have high tensile strengths and are resistant to all chemical substances present in soils. 6 refs.

UK
Accession no.268063

DESIGNING WITH TENSAR: TECHNIQUES AND DESIGN PHILOSOPHY FOR UTILISING TENSAR GRIDS IN THE REINFORCING OF SOIL STRUCTURES NETLON LTD.

Detailed descriptions are given on the use and placement of Tensar reinforcing materials for use in soil stabilisation and other civil engineering projects. Tensar is of a highly oriented polymer, with high tensile strength and chemical resistance. 6 refs.

UK
Accession no.268061

TENSAR GEOGRIDS: SPECIFICATION DATA FOR NETLON CIVIL ENGINEERING PRODUCTS, TENSAR SR2 AND SS3 GEOGRIDS NETLON LTD.

Data is given on Netlon PE and PE net and grid products for use in ground stabilisation applications. Particular reference is made to dimensions, mechanical properties, chemical composition and resistance, biological resistance, thermal stability and resistance to sunlight. Applications are listed. Specification data is provided on both Tensar SR2 Geogrids and Tensar SS3 Geogrids.

UK
Accession no.266450

COATED FABRICS IN GEOTEXTILE AND GEOMEMBRANE APPLICATIONS
Fluet J E
GEOSERVICES INC.

A discussion is presented of the use of coated fabrics to modify the behaviour of soil and its associated fluids in a geotechnical system. Statistics are presented on market growth of geomembranes in the U.S. for 1980-1983. 8 refs.

USA
Accession no.265659

GEOTEXTILE TRENDS IN END USE AND DEVELOPMENT
Warwick R G
LOW BROS. & CO. (DUNDEE) LTD. (PRI)

An overview of current geotextile use and near future directions of development for mainstream uses only is presented. Consideration is given to polymer and fabric types, drainage and filtration, erosion protection and use of geotextiles in roads and railways. 2 refs.

UK
Accession no.263173

ROLE OF GEOTEXTILES IN THE DYNAMIC FILTRATION OF ROAD PAVEMENTS
Saunders A T; Bell A L; Green H M
BELFAST, QUEEN’S UNIVERSITY; LAMBEG INDUSTRIAL RESEARCH ASSOCIATION (PRI)

The background to drainage and filtration problems in road pavements is described and the use of geotextiles to prevent contamination is discussed. The types of sub-base filters available are outlined and the performance of geotextile/granular composite filters assessed. The
significant requirements for a suitable geotextile filter are now known to include permeability, pore size, thickness, structure, incompressibility, TS and deformation resistance. 7 refs.

UK
Accession no.263172

Item 403
Polypropylene Textiles; Conference.
CARPET BACKING, INDUSTRIAL, AND GEOTEXTILE FABRICS FROM POLYPROPYLENE
Young J B
DON FIBRES LTD.
(Shirley Institute)
A detailed description is given of the development of woven PP fabrics in carpet backing, industrial fabrics and geotextile applications.
UK
Accession no.263149

Item 404
Plastics in Building Construction
8, No. 5, 1984, p. 7-12
COATED FABRICS IN GEOTEXTILE AND GEOMEMBRANE APPLICATIONS
Fluet J E
GEOSERVICES INC.
A review is given of the use of geotextiles and geomembranes in civil engineering applications such as road construction, soil stabilisation, drainage, forestry, erosion control and mining applications. Mention is given to the market growth in the US. 8 refs.
USA
Accession no.260903

Item 405
Ground Engineering
17, No. 3, April 1984, p. 29-32
GEOTEXTILES AS EARTH REINFORCEMENT IN THE UNITED KINGDOM
Ingold T S
LAING J., RESEARCH & DEVELOPMENT LTD.; QUEEN’S UNIVERSITY OF BELFAST
Consideration is given to the use of synthetic geotextiles in soil reinforcement applications in the UK. Materials examined include Terram RF/12 unidirectional polyester fabric (ICI), Lotrak 16/15 woven, extruded PP tape (Low Bros.), and CE131 extruded PE mesh and Tensar SRI and SR2 oriented HDPE mesh geogrids (Netlon Ltd.) Applications described include embankment and walls reinforcement, brick and gabion wall reinforcements, and remedial works in motorway cutting slopes.

ICI FIBRES LTD.; LOW BROS. & CO. (DUNDEE) LTD.; NETLON LTD.
UK
Accession no.254836

Item 406
Plastics and Rubber Processing and Applications
4, No. 2, 1984, p. 99-104
APPLICATION OF HIGH STRENGTH POLYOLEFIN GRIDS IN CIVIL ENGINEERING
Templeman J E; Sweetland D B; Langley P A
NETLON LTD.
This article describes the manufacture of polyolefin grid structures, with tensile strengths equal to mild steel. Application in increasing the load bearing strength of weak soils and reinforcing soil in earthworks for foundations, embankments and retaining walls is discussed, while the improved rutting resistance of asphalt road surfacing with polymer grid inclusion and crack control provided by the grids is also demonstrated. Properties of cement composite structures containing polymer grids are illustrated. 9 refs.
UK
Accession no.253922

Item 407
Polysar Progress
Sept./Oct. 1983, p. 4
STRICTER STANDARDS FOR ‘GEOMEMBRANES’ TO HOLD LIQUIDS IN PONDS, RESERVOIRS
The use of synthetic rubber and plastic materials as geomembranes to line water reservoirs, irrigation canals, sewage lagoons, industrial waste pits and solar energy ponds is discussed. The service conditions which these membranes are required to endure are described including compatibility with and impermeability to, the fluid being contained, weathering and UV resistance and flexibility at temp. extremes. Two of the most widely used rubbers are claimed to be EPDM and butyl. For special needs, such as contact with hydrocarbons, oil-resistant nitrile rubbers are used in blends with PVC.
POLYSAR LTD.
CANADA
Accession no.244255

Item 408
Chemical Week
131, No. 22, 1st Dec. 1982, p. 54-5
REBUILDING THE MARKET FOR HIGHWAY REPAIR
Details are given on new materials which are being developed for highway repair in the USA. Current costs for maintaining roads is approximately 500 million dollars a year over 3.85 million miles of roads and streets.
Materials, developed by Du Pont are Typar spun bonded PP for soil stabilisation and Reepav spun bonded polyester fabric for resurfacing. Phillips have developed Petromat and Petrolac which are already proved in highway construction. Details are given regarding these materials which include statistics.

DU PONT DE NEMOURS E.I.,& CO.INC.; OWENS CORNING FIBERGLASS CORP.; PHILLIPS PETROLEUM CO.
USA

Accession no.223972

Item 409
CONFER. 012

STABILISATION OF SOIL IN COASTAL AND WATERWAY STRUCTURES
Templeman J E; Sweetland D B

The applications of polymer meshes, polymer grids and geotextiles in the stabilisation of coastal and waterway structures are reviewed. Aspects covered include enhancement of natural beach and waterway protection, soil reinforcement, control of windblown sand, construction of foundation mattresses for building large earthworks on weak soils and increasing the load-bearing properties of weak soils for gaining access and for construction purposes, and containment of stone for shore and waterway armouring. 12 refs.

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