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GEOTEXTILES FOR FOREST ROADING

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Figure 1 : Geotextile as a separation layer between subgrade and basecourse on a forest road

ABSTRACT

Geotextiles have been used in the New Zealand forest industry for fifteen years. There is still a misunderstanding as to the benefits which can be obtained by using this material. Because of this misunderstanding of what geotextiles can do, the consequent poor field performance is not necessarily indicative of their value.

Types of geotextiles, uses, and a review of the design methods are presented. Also some practical advice on the use of geotextiles in forest roading is offered.

INTRODUCTION

Efforts to reinforce soils with other materials have been made over many hundreds of years. The Romans used

animal skins in some of their construction works and the use of "corduroy" under roads dates back to 3000 B.C. Corduroy roads using logging residue, split logs and mill slabs have been widely used in New Zealand forests and the practice is still seen in some parts of the country.

The use of fabrics in New Zealand forest roads is relatively new and dates only from the mid 1970s.

Geotextiles is the name universally adopted for fabrics used in geotechnical engineering. Over the past ten years a wide range of geotextiles have been available in New Zealand.

Because there is a belief (or hope) that geotextiles may solve roading problems in many situations when conventional methods are too expensive, the use of this product has not always been rational and is not always based on sound engineering principles.

This short Report takes a rational look at the use of geotextiles in forest roading, and promotes the sensible use of a very valuable product.

TYPES OF GEOTEXTILES

The geotextiles commonly available are in a variety of fabric styles which can be categorised as:-

Non Woven - like felts

Woven - various weaves. (Horticultural Shade cloth, which is familiar to many, is a woven cloth.)

Knitted

The fibres or yarns making up the fabrics can be made from the following materials:

(a) Polypropylene
(b) Polyester
(c) Polyamide (nylon)
(d) Polyethylene
(e) Glass
(f) Others

Most are derived from hydrocarbons and the petrochemical industries are the suppliers of the base materials used in their manufacture.

The chemical and environmental properties of the fibres are dependent on the type of polymer used in the geotextile construction.

The engineering properties of the fibres, such as strength, are dependent on both the type of polymer and the process used in the manufacture. Hardening, stretching and other factors all have an effect on the fibre's engineering properties.

The individual fibres are often combined into yarns (similar to making ropes or twines) and all of the following are commonly used in geotextile manufacture.

(a) Monofilaments (single strand)

(b) Multifilaments (multiple strands often twisted together)

(c) Staple (in which short [<100mm] fibres are twisted or spun into longer yarns)

(d) Staple yarns

(e) Slit films (a continuous sheet of film [like building plastic] is slit by knives to form ribbonlike fibres).

Woven fabrics are made from these fibres on conventional weaving machinery.

Spun bonded fabrics are made from these fibres by laying the fibres on a moving belt and bonding the fibres together by thermal, mechanical or chemical treatment.

Melt bonded fabrics have the fibres bonded at filament crossover points.

Needle punched fabrics are produced by punching fibrous web of the desired type with special needles.

Composite geotextiles (i.e. a geotextile cloth may be combined with an impermeable plastic or rubber membrane) are also available in a wide variety of types.

The petrochemical and textiles industries are large and many special products are available. No doubt many more will become available in the future as they are developed.

The commonly available synthetic geotextiles may be susceptible to attack or modification by:-

(1) Temperature

(2) Chemicals (even common ones such as diesel oil)

(3) UV light and weathering

(4) Bacteria

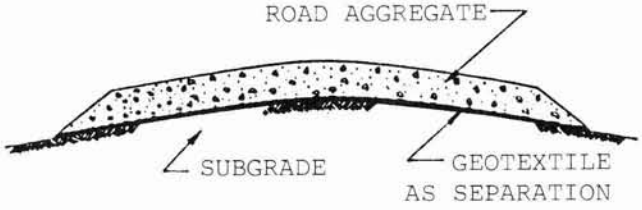
When considered along with mechanical deterioration from such actions as abrasion (as would happen under a roading aggregate subject to movement) it is obvious that care and careful enquiry should be made before any particular geotextile is used to ensure the best possible field performance.

GEOTEXTILE FUNCTION

In forest roading, geotextiles are generally used by placing them between the aggregate layer forming the base course and the subgrade soil.

They can perform various functions which are usually categorised as:

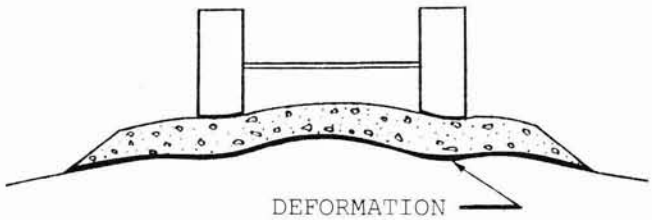
(a) **Separation** - in which the geotextile is introduced between dissimilar materials so that the integrity and function of the materials is retained.



The establishment of a stable road base depends on how well the subbase integrity is maintained. Any mixing of the quality roading aggregate and the subbase material, which is often wet, should be avoided at any reasonable cost, so that the road basecourse can perform its design function.

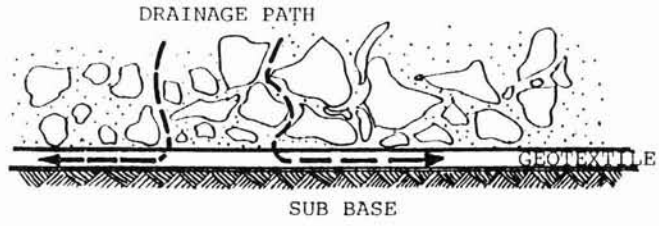
Separation of basecourse and subbase is desirable in all cases but it becomes essential when the subbase is a difficult one, i.e. wet soft clay, silt etc.

(b) **Reinforcement** - in which the high tensile strength of a strong geotextile is mobilised by the relatively high deformation of the subbase soil and geotextile.



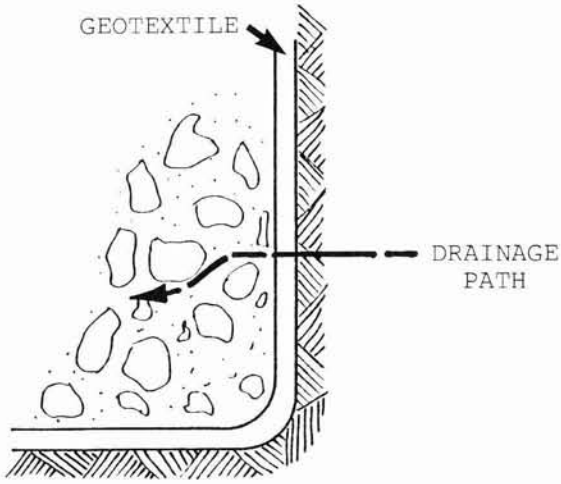
Reinforcement modifies the distribution of loads to the subgrade soil and any use of geotextiles in this capacity involves extensive and difficult design procedures.

(c) **Drainage** - in which the geotextile allows the flow of water along the fabric plane.



In drainage applications thick geotextiles or special geotextile - geomembrane composites are often used, although some flow of water is possible along the fabric plane even while the primary purpose of the geotextile is one of separation.

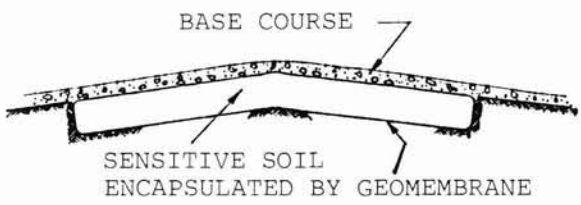
(d) **Filtration** - in which the geotextile allows the free flow of water across the plane of the fabric.



Conventional drainage design uses specially graded granular material. In draining the soil, this granular material is both a filter and a conductor of water.

Because the requirements for best water conduction conflict with those for filtration, granular drainage design is a compromise. A combination of granular and geotextile design can often provide a better and cheaper alternative which will have less risk of failure, even when installed using simple methods and under less than optimum field conditions.

(e) A special use of impervious geomembranes in roading is as a Membrane Encapsulated Soil (MES).



In this application the geomembrane completely encapsulates a soil to prevent excessive moisture variations. It can be used to stabilise frost sensitive soils, expansive clays, and substandard soils.

DESIGN METHOD

For use as a separation layer:

Geotextiles are most commonly used in roading to perform a separation function. It may however be the primary role or merely as an adjunct to its use in a different primary role.

In forest roading it is likely that separation will be the primary use of geotextiles because of the cost of high strength fabrics and the specific subgrade conditions required to develop the tensile ability of the fabric.

If specific design is to be attempted then Koerner (1986) covers most of the detail required. An Engineering background will be a prerequisite for using his procedures.

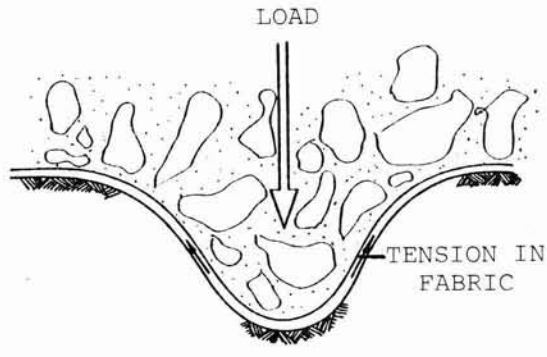
The areas which must be considered in designing a geotextile separation layer are:

(1) Burst resistance
(2) Tensile strength
(3) Puncture (Tear) resistance
(4) Impact resistance
(5) Abrasion resistance

For use as a reinforcement

To use geotextiles as reinforcement under forest road surfaces requires, in particular, a very careful consideration of the subsoil type.

The geotextile must have its tensile strength mobilised by deformation. It can be done intentionally by prestressing the fabric and pinning it in place. The normal procedure is to allow subgrade yielding as shown in the Figure.



The amount of deformation required along with other factors such as the effect of repetitive loading, impact loading, and so on, mean that only broad generalisations are possible in assessing the subsoil suitability for reinforcement by geotextiles.

As a general rule subgrade CBR's from 3* downward may be suitable, with the reinforcement aspect becoming more important as the CBR decreases i.e. soil gets weaker).

MANUFACTURER'S DESIGN METHODS

Most manufacturers provide design methods for use with their fabrics. These can, and should be used. Difficulties will arise when trying to compare designs, because a variety of fabrics from different manufacturers are being considered and the fabric properties and design assumptions can vary widely.

Analytic Methods

Some analytic or semi-analytic methods are available but all require an engineering background for their use.

General

Many of these design methods will result in quite small savings (<100mm) of stone base and many depend on the development of high rut depths (up to 300mm).

From the point of view of the Forest Roading Supervisor these small savings in stone depth may not be significant and the high rut depths are unacceptable in any but a special purpose road.

Design methods by Nicolon Corporation (Tour) show the use of small aggregate base depths for quite substantial wheel loading. Their fabrics are rather special and not available in New Zealand. Therefore, their design method should not be used.

** A clay with a California Bearing Ratio (CBR) of 3 requires moderate effort to penetrate with a thumb or finger.*

GEOTEXTILE COST VS AGGREGATE SAVINGS

Any design method, for whatever purpose; reinforcement, separation, drainage or filtration, must weigh costs against benefits.

In road design for reinforcement or separation this reduces to:

"How much aggregate cost is saved by spending X dollars/m^2 on geotextiles".

In order that this calculation can be performed rapidly without fear of errors the following notes and graph will be of some assistance.

Consider

A. How much aggregate depth is saved? When costing, allow for :

(1) Cartage
(2) Spreading and grading
(3) Compaction
(4) Waste at the edges of the road
(5) General construction loss

B. How much the geotextile costs per square metre? Allow for:-

(1) Purchase price
(2) Transport
(3) Storage
(4) End overlaps
(5) Side overlaps

C. Using the Graph in Figure 2

(1) Select geotextile cost on bottom.

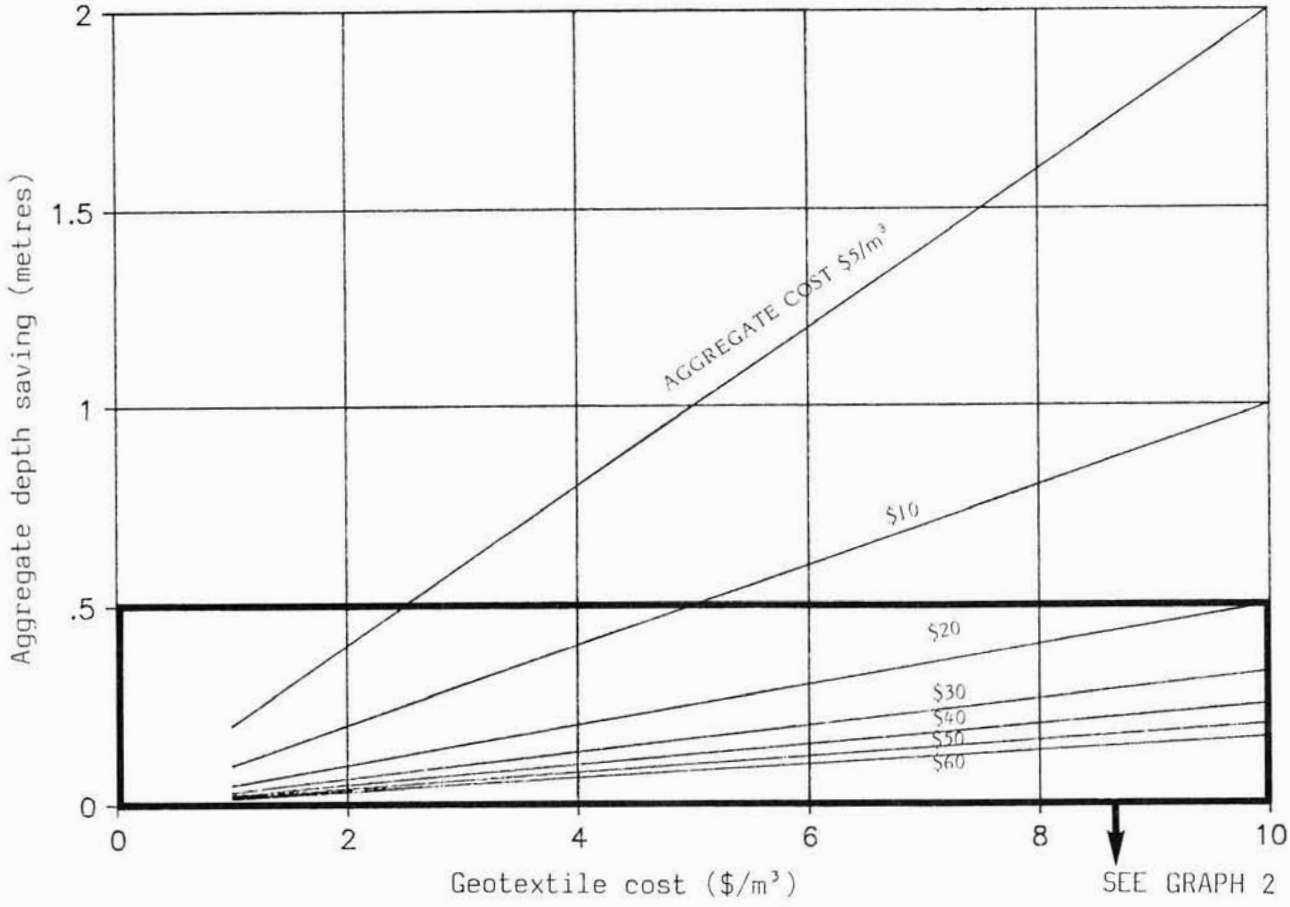
(2) Go vertically up until you reach the line of aggregate cost for your needs.

(3) Go horizontally to the left to read off the required depth saving necessary to "break even".

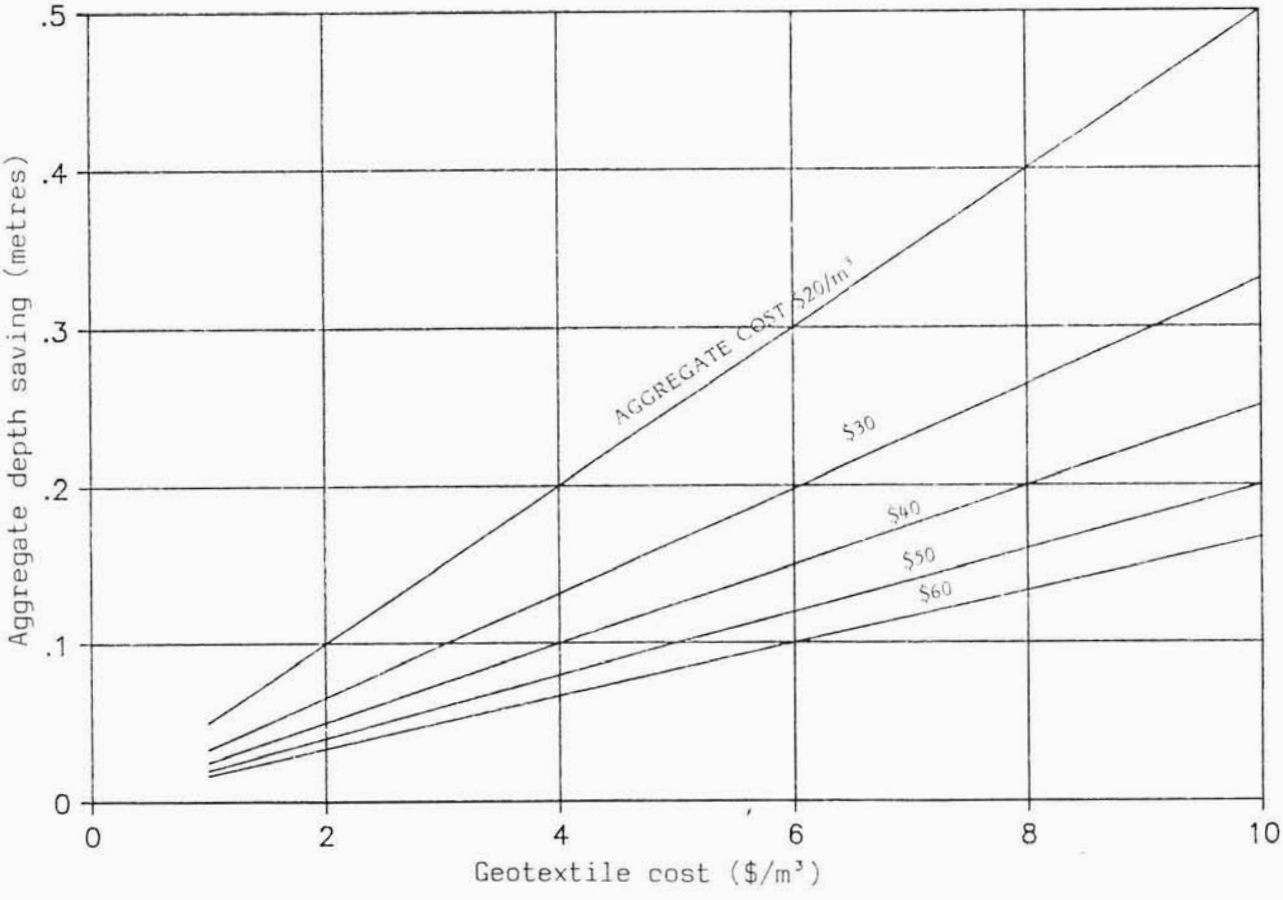
Example

Geotextile cost $\$ 3.50/m^2$
Aggregate cost $\$35.00/m^3$

Required saving in aggregate depth = .10m



GRAPH 1



GRAPH 2 - Geotextile Cost versus Aggregate Savings

Remember that the aggregate cost being used here is that of compacted - in place - aggregate. A compaction factor of 1.2 - 1.4 should be allowed for when doing conversions between "in place" aggregate and "truck measure".

Allowance should also be made for losses of aggregates in stockpile (10%) and edge loss in road construction (varies with road width).

PRACTICAL TIPS ON THE USE OF GEOTEXTILES

(1) Geotextiles are not a panacea for all ills in forest roading. They should be considered for use when :

(a) The ground conditions are very wet. In some instances the cost of the geotextile can be justified just during the contruction phase, although this is most evident on expensive construction.

(b) Some special property only available by the use of geotextile is required, i.e. clay basecourse separation.

(2) 300 mm is the practical minimum cover for geotextiles (Figure 3).

(3) Care must be taken when laying the base course to ensure the fabric is not punctured. Figure 4 shows a good approach to construction over geotextile.

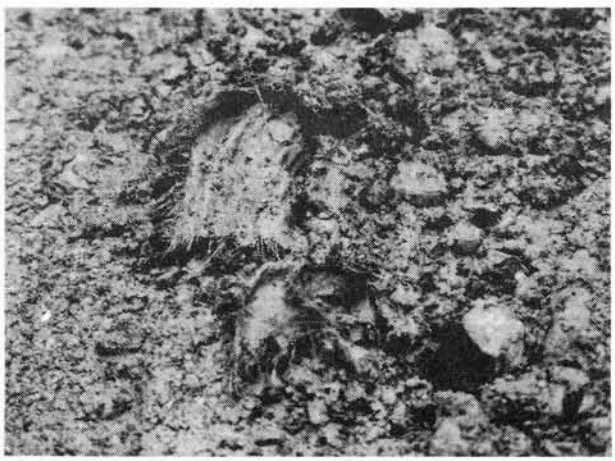


Figure 3 : The result of inadequate aggregate covering - burst geotextile. The aggregate is still very wet and has not gained in strength through the use of geotextile.

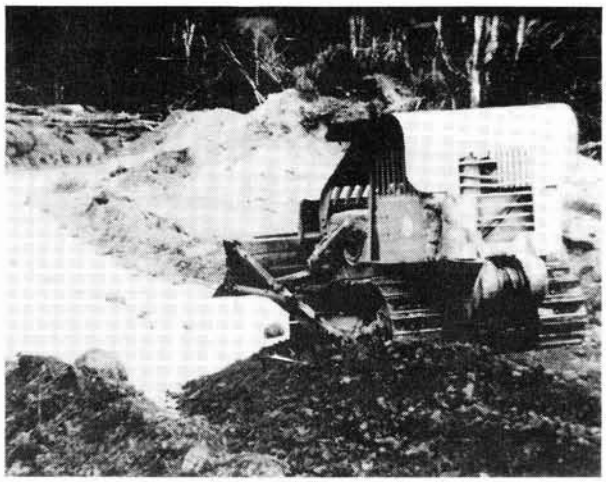


Figure 4 : A good depth of material over a neatly laid geotextile, which is being used as a separation layer between clay and good quality roading material

(4) When joining geotextiles, the joints should be either sewn or plenty of overlaps should be left to allow for any subsequent cloth displacement.

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