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Contents

Introduction 1
Methodology 1
Performance 3
Cost analysis 3
Implementation .. 4
Acknowledgments 4
References 4

Applicability of geosynthetics for the reinforcement of forest roads in muskeg bogs

Abstract

Geosynthetic reinforcement was evaluated in a road that crossed a muskeg bog. Three options were tested: geogrid, reinforced non-woven geotextile, and corduroy (delimbed trees laid side by side). After 1 year, the three road segments provided similar performance. Geosynthetics were less expensive than corduroy if the stems used in the latter approach could have generated a net profit of greater than $3/m³. Geosynthetics are easy to install, require no additional equipment during the installation, and avoid fiber loss.

Keywords:

Geosynthetic reinforcement, Reinforced non-woven geotextile, Geogrid, Corduroy, Comparison, Muskeg, Soils with low bearing capacity, Forest roads.

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Introduction

In 2001, the use of geosynthetic reinforcement in road construction in a muskeg bog was studied by FERIC and SAGEOS (a lab that specializes in geosynthetics) near Daaquam (Que.), in collaboration with Bois Daaquam inc., Solmax-Texel, and Tensar Earth Technologies Inc.; the road's behavior was then monitored during 2002. We compared geogrid, reinforced non-woven geotextile, and corduroy (delimbed trees laid side by side) in the construction of the road that crossed a muskeg bog.

FERIC has already studied the use of geosynthetics as a separator layer (Provencher 1992). For soils with very low bearing capacity, stronger products are required to offer both *separation* and *reinforcement*. Roads managers often avoid muskeg bogs by planning longer roads that circumvent these problem sites. However, this approach can be more expensive than using geosynthetics, and the present study was designed to identify contexts in which using these products would be economical. This report describes the performance of these products in a field trial, analyzes their economics, and provides recommendations on their use.

Methodology

Selection of geosynthetics: Geosynthetics used for subgrade reinforcement on soft soils must provide good friction against the soil and good rigidity under tension (i.e., little stretching prior to rupture). At least two types of product meet these criteria: geogrids and reinforced non-woven geotextiles. Conventional geotextiles used for separation do not serve well in this application because they generally fail to meet these criteria.

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This project was a collaborative effort by FERIC and SAGEOS, with assistance from the "partnership funding" program of Quebec's Ministère de l'Industrie et du Commerce.

In planning the work, managers must carefully calculate the thickness of fill that will lie on top of the reinforcement to ensure that this layer will be adequate. Free software available from geosynthetics distributors can rapidly perform the necessary calculations and guide users in determining the minimum acceptable thickness, which depends on the following parameters:

- type of geosynthetic
- anticipated traffic
- bearing capacity of the soil (typically a CBR <1 for a muskeg bog)
- CBR of the fill material (Hamilton 2000)
- the maximum rutting that can be tolerated (typically 75 to 100 mm), and
- operational constraints; for example, even if the calculated required thickness is very low, a minimum thickness must still be provided to prevent graders from damaging the geosynthetics.

Study conditions: The trial was conducted on a primary road (Class I) that ran through a muskeg bog (Figure 1) less than 3 km from the mill yard, thus traffic was heavy. It was impossible to run the road around the site. The swamp was relatively deep (around 1 m), and the presence of surface water required the installation of several culverts. For practical reasons, the road had to be built in early fall, when 10 cm of water covered the moss.

Figure 1. The study site.

Conduct of the operation: We tested the options in Figure 2: geogrid (Tensar BX1100), reinforced non-woven geotextile (Texel Géo-9), and corduroy (the traditional solution). The corduroy approach has the advantage of requiring no additional purchases, but its disadvantages include the need for additional equipment to handle and haul the wood, fiber loss, and the lack of any filter between the fill material and the muskeg bog's water.

An advantage offered by geosynthetic reinforcements is that installation requires only the equipment already present for road construction. Two to three workers can unroll and assemble geogrid by linking the rolls together using plastic fasteners every 1 to 2 m; around four workers were required to unroll and deploy the reinforced non-woven geotextile, which had been preassembled (sewn together) at the fabric mill. It's preferable to cut any brush taller than 45 cm before installing the geosynthetics to facilitate unrolling the materials and avoid perforating the geotextile.

The installation method was efficient. Fill material was delivered by truck, dumped across the entire width of the road to avoid slippage of the geosynthetics, and spread by a bulldozer. The minimum required thickness of fill must be provided before travel can begin on the road. The fill used should not be plastic, and should be as coarse as possible to provide good drainage (a classification of SP or better; Hamilton 2000). This aspect is particularly important where upwelling of water would impede vehicle travel. With fine materials (SM or above), as in the present study, construction should thus proceed more slowly to let water drain as the fill is added. When fine-textured fill materials are installed directly above the muskeg bog's water table, as in the

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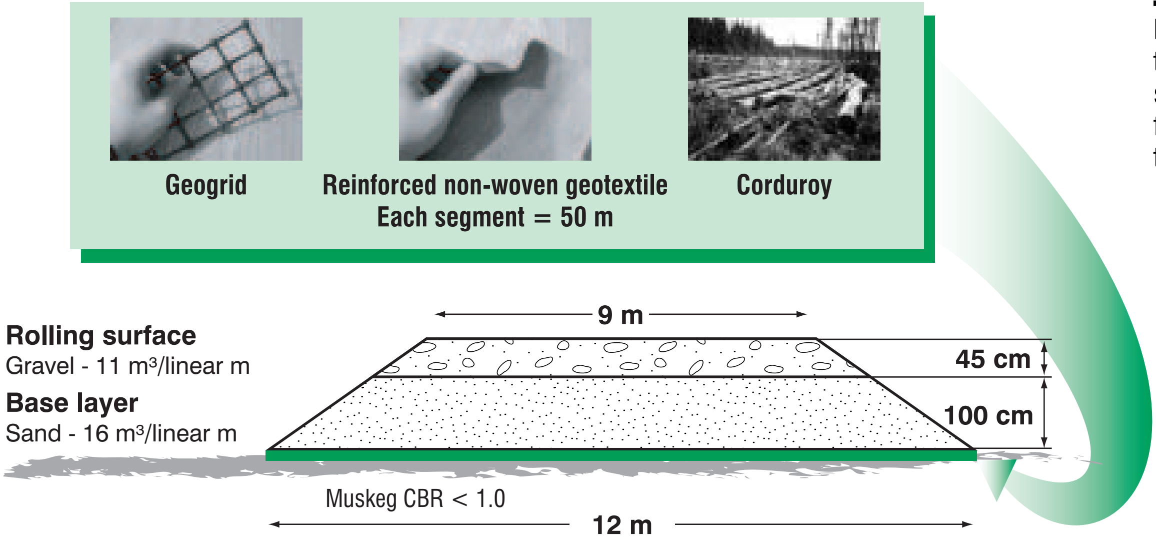

Figure 2. The road structures installed during the study (geogrid, reinforced non-woven geotextile, and corduroy).

present study, the upwelling water decreases their bearing capacity. This problem can sometimes be avoided by scheduling work during drier periods.

Performance

Installation: Because the geosynthetics were easily installed without requiring heavy equipment, there was no significant time loss during the installation. In contrast, the corduroy took around twice as long to install and also required workers to wait for a loader to become available. However, good planning can reduce these time losses.

We encountered problems with reduced bearing capacity resulting from the poor drainage, since the fill used was very fine-textured. Vehicle traffic was compromised for several hours after installation of the first layers of fill, but once excess water had drained away, the fill regained sufficient bearing capacity and the work proceeded smoothly.

Preassembly of the reinforced non-woven geotextile into 12-m widths offered practical advantages, including the fact that this avoided the need to overlap two rolls, which would also have required a larger quantity of geotextile to provide the same coverage. However, it's important to ensure that the stitches in preassembled material are as strong as the material itself. The geogrid rolls were lighter than the geotextile roll and thus easier to handle.

Performance: The three solutions we tested offered comparable performance 1 year after installation. The weaknesses observed during road construction had disappeared, and the three road structures all provided good performance. No settling of the fill and no decreases in its bearing capacity were observed (Figure 3). Similar, low levels of rutting were observed for all three road structures. Only a few depressions were observed, and these were not found where adjacent road structures came together; instead, they were caused by the nature of the fill material used and the weather conditions during installation.

Cost analysis

The geosynthetics used in this study cost an average of $3/m² (including $0.50/m² for installation), but this cost varies with the quantity purchased and the delivery distance from the dealer to the customer. For a 12-m-wide subgrade, around 15 m of products are required to provide sufficient overlap of rolls if

Figure 3. State of the road after 1 year.

the material is not preassembled. We recommend using pre-sewn rolls to reduce costs (this approach requires less of the product) and to facilitate installation. Figure 4 compares the costs of using geosynthetics versus corduroy. The corduroy's installation cost included felling the trees, extraction to roadside, installation by a loader (a fixed cost of $350 for tying up the machine, irrespective of the length of road segment) and stumpage costs of $10/m³ (a value that varies from region to region). The analysis assumed a mean volume per tree of 0.6 m³, as was the case during the study.

Figure 4 also includes the estimated installation cost for corduroy based on the potential lost income (ranging from $0 to $10 per m³) from the stems used in the road. A conservative estimate would be around $5/m³. Figure 4 shows that:

- With no merchantable value for the trees, geosynthetics have comparable costs to corduroy for road segments shorter than 50 m.
- With a net value greater than $3/m³ for the trees, geosynthetics are less expensive for any length of road segment.

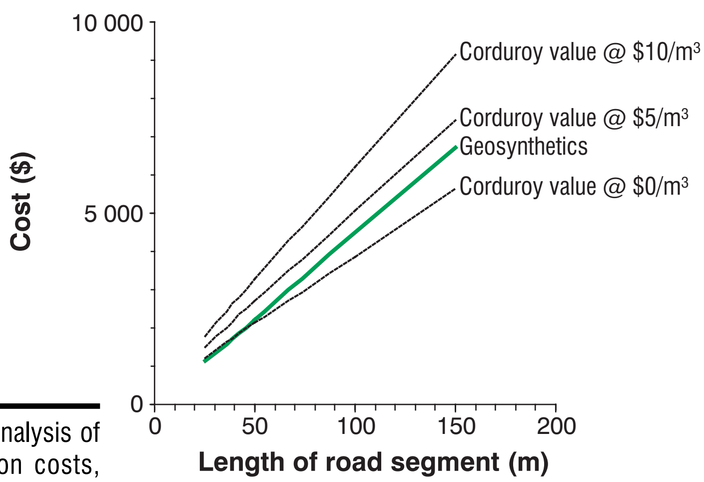

Figure 4. Analysis of construction costs, excluding fill.

Implementation

Geosynthetic reinforcements offer an effective solution for roads built on soft soils such as those in muskeg bogs, approaches to streams, or other problem areas. Other advantages can be expected, such as reduced fill requirements. These other factors were not documented in the present project.

The advantages offered by geosynthetics in road construction include the following:

- a practical and functional method
- no requirement to tie up harvesting equipment
- reduced fiber loss, and
- an economical choice when the net value of the fiber is more than around $3/m³, or for road segments shorter than around 50 m.

For the efficient use of geosynthetics, we recommend that you:

- Ensure that when fill material is spread above a soil saturated with water, the material used is as coarse as possible to avoid drainage problems during construction.
- Calculate the minimum thickness of fill using design software provided by the material's distributors. (FERIC or SAGEOS can also perform these calculations on request.)
- Include at least one person on the work crew who understands the appropriate installation method to use.
- Plan the installation of geosynthetics at the same time as any required culverts to ensure that the required personnel are available.

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