

Basic Geosynthetics: A Guide to Best Practices in Forest Engineering

Jonathan Fannin

Ph.D., P. Eng., Forest Resources Management and Civil Engineering, University of British Columbia, Canada.

ABSTRACT - Geosynthetics are used in forest engineering applications for soil stabilization, where the basic functions are reinforcement, separation, filtration and drainage. In many routine applications, the basis for selection of an appropriate geosynthetic is with reference to standard specification documents, using material properties reported by the manufacturer. Recommendations for best practices in such routine applications are reported, from a detailed case report involving stabilization of a cutslope. Further considerations are identified from additional construction applications that include roads, stream channels, a trench drain and log culverts.

Keywords – Geotextile, material properties, specification, installation, best practices.

INTRODUCTION

Geosynthetics are increasingly used to stabilize soils in forest engineering applications. The applications date back over 25 years, and indeed, geosynthetics were first used in construction of geotextile reinforced walls supporting logging roads the northwestern United States in 1974 (Berg et al., 1998). A subsequent 1977 U.S. Forest Service (USFS) manual described procedures for the selection and specification of geotextiles for applications of filtration, separation, subgrade restraint and soil reinforcement (Steward et al., 1977). More recently, a 1994 USFS manual includes guidance on the use of geotextiles and geogrids for (i) retaining walls, (ii) embankments and (iii) repair of loose sidecast roadfills that often contain old organic debris with a reinforced “deep patch” (Mohoney et al., 1994).

A proper evaluation of the proposed use, materials specification, and installation procedures is important to good construction practices. Geosynthetic stabilization of soils involves four basic functions of reinforcement, separation, filtration and drainage. The relative importance of each function is governed by the site conditions, especially soil type and groundwater drainage, and the construction application. In many cases, two or more basic functions are required of the geosynthetic in a particular application (for example, separation and filtration).

A new guide to “best practices” (Fannin, 2000) describes the selection, specification and installation of geosynthetics in forest engineering projects. Specifically it addresses the use of geotextiles and geogrids, with guidance drawn from a review of ten construction case reports. Objectives of the guidance are two-fold. Firstly, to assist users to exercise their professional judgement and experience in developing site-specific recommendations. The construction case reports are provided to illustrate some important points. Secondly, to promote the use of best practices in construction. Examples are drawn from the selected case reports.

A synthesis of forest engineering applications, the specification of geosynthetics and best construction practices is given below. The intent is to provide a firm understanding of current practices in forest engineering, and to review the scope of experience and recommendations contained in the new guide.

FOREST ENGINEERING

The construction applications that are addressed in the “best practices” guidance include unpaved roads, log-culverts, slope stabilization, subsurface drainage, riprap revetments, and bridge abutments (see Table 1). In each application, the relevant contribution of the geosynthetic to soil stabilization is governed by its material properties. These properties are used to quantify the strength, hydraulic characteristics and durability of the geosynthetic. They determine the benefit to be gained through improved reinforcement, separation, filtration and drainage of the soils. Material properties are the basis for product selection and, therefore, are referenced in standard specification documents, for example the Geotextile Specification for Highway Applications (AASHTO, 1998).

Table 1. Geosynthetic applications and the basic functions

REINFORCEMENT	SEPARATION	FILTRATION	DRAINAGE
	<ul style="list-style-type: none"> • Unpaved road construction 		
	<ul style="list-style-type: none"> • Log-culvert deck • Cutslope stabilization 		
		<ul style="list-style-type: none"> • Trench drain 	
	<ul style="list-style-type: none"> • Riprap revetment 		
<ul style="list-style-type: none"> • Fill slope stabilization • Bridge abutment (retaining wall) 			

SPECIFICATION OF GEOSYNTHETICS

Properties used in the specification of geosynthetics, are established from index tests or from performance tests (see Figure 1):

- index tests are used by manufacturers for quality control, and by installers for product comparison, material specifications and construction quality assurance;
- performance tests are used by designers to establish, where necessary, a property under specific conditions using soil samples taken from the site .

Index tests describe the general, strength, hydraulic and durability properties of the geosynthetic. General properties are used to distinguish between polymer type and mass per unit area. Mechanical strength properties (for example, the Grab, Tear, Puncture or Burst strengths) simulate the resistance to loading induced during installation, and to loading imposed during the service life of the project. Hydraulic properties describe the capacity of the geotextile for cross-plane flow of water, termed Permittivity, and the opening size of the

fabric (for example, the Apparent Opening Size or the Filtration Opening Size) as it relates to soil retention for erosion control. Durability properties are used to quantify the endurance of the geosynthetic during and after construction: the potential for a degradation of strength over time, with exposure to ultraviolet (UV) light, is a factor for consideration in design.

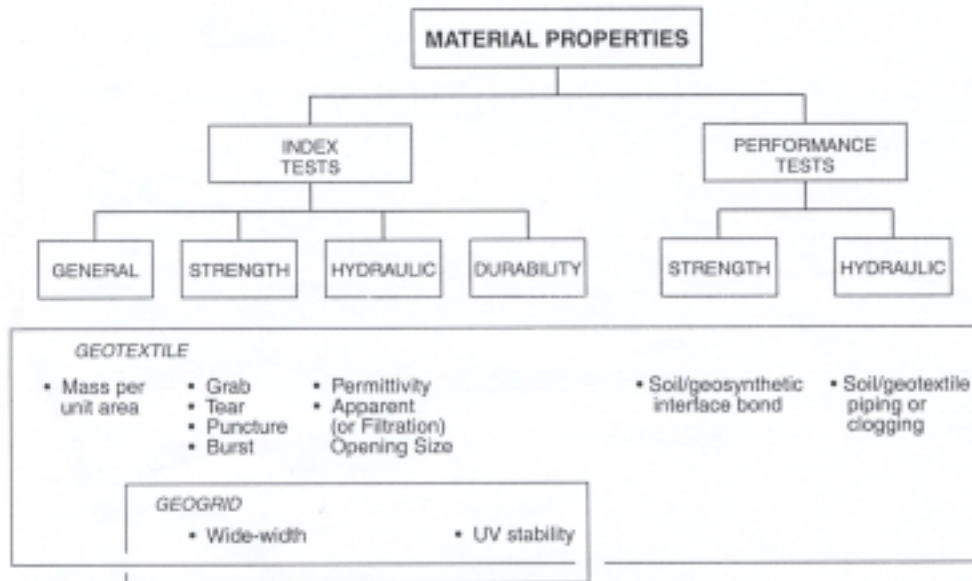


Figure 1. Standard test methods

Performance tests are typically used to assess mechanical and hydraulic properties for design parameters governing soil/geotextile interaction (for example, interface bond that governs anchorage capacity, and the potential for piping or clogging of a geotextile filter). They are site specific properties that are determined from specialist laboratory tests.“

“BEST PRACTICES” IN CONSTRUCTION

Fannin (2000) reports the findings of a review of ten forestry projects in which geosynthetics were used. Some of the ten construction case reports describe non-critical applications (see Table 2, CR #1 to CR #8). Others are more critical applications, for example engineered structures such as reinforced soil slopes and bridge abutments, for which the specification of material properties is governed by specialized codes of practice and proprietary design guidance (Table 2, CR #9 and CR #10).

The ten construction case reports follow a standard format that provides a project overview, followed by a companion geosynthetic summary.

The project overview comprises:

- a summary of the general site conditions;
- a soils description;
- the rationale for using a geosynthetic; and,

- the construction procedure followed during installation.

The geosynthetic summary comprises:

- the type of geosynthetic type;
- a list of material properties;
- a comparison to the AASHTO standard specification document (1998), where appropriate; and,
- a series of construction “best practices”.

Table 2. Forest engineering case reports

Case Report	Application	Geosynthetic
CR # 1	Road	<i>Nonwoven Geotextile</i>
CR # 2	Road	<i>Woven Geotextile</i>
CR # 3	Road	<i>Biaxial Geogrid</i>
CR # 4	Log-Culvert Deck	<i>Nonwoven Geotextile</i>
CR # 5	Cutslope Stabilization	<i>Nonwoven Geotextile</i>
CR # 6	Trench Drain	<i>Nonwoven Geotextile</i>
CR # 7	Bank Stabilization	<i>Nonwoven & Woven Geotextile</i>
CR # 8	Channel Stabilization	<i>Nonwoven Geotextile</i>
CR # 9	Fill Slope Stabilization	<i>Uniaxial Geogrid</i>
CR # 10	Bridge Abutment	<i>Uniaxial Geogrid</i>

Each of the ten project overviews is accompanied by two photographs from site (see, for example, Figure 2). The images were selected to illustrate key aspects of the installation and the as-placed arrangement of the geosynthetic. Each of the companion geosynthetic summaries is accompanied by two figures, drawn from the site photographs, which annotate features relevant to the photograph and related “best practices” (see, for example, Figure 3).

This particular case report describes stabilization of a cutslope. Constraints to a new road alignment require a high cutslope on a steep section of potentially unstable hillslope. Existing failures were noted in a terrain stability assessment prior to construction. The cut is made through erodible soils. The cutslope angle varies between 35° and 45° (70 % and 100 %). The maximum vertical height above road grade is 6 m. The section of road is adjacent to a stream gully. Groundwater seepage at various horizons on the exposed soil face may cause local instability. Final construction is to provide permanent site access.

Special provisions are required to prevent the development of an unstable, eroding cutslope. The subgrade soil is a broadly-graded, very gravelly sand, with a trace of silt. The approach used was to place a rock blanket along the cutslope. The rock blanket is an angular blast rock, for which $D_{50} = 0.6$ m and $D_{100} = 1.1$ m. The seepage conditions require the geosynthetic provide coincident functions of separation and filtration. A needle-punched nonwoven geotextile was specified.



Figure 2. Placing the geotextile

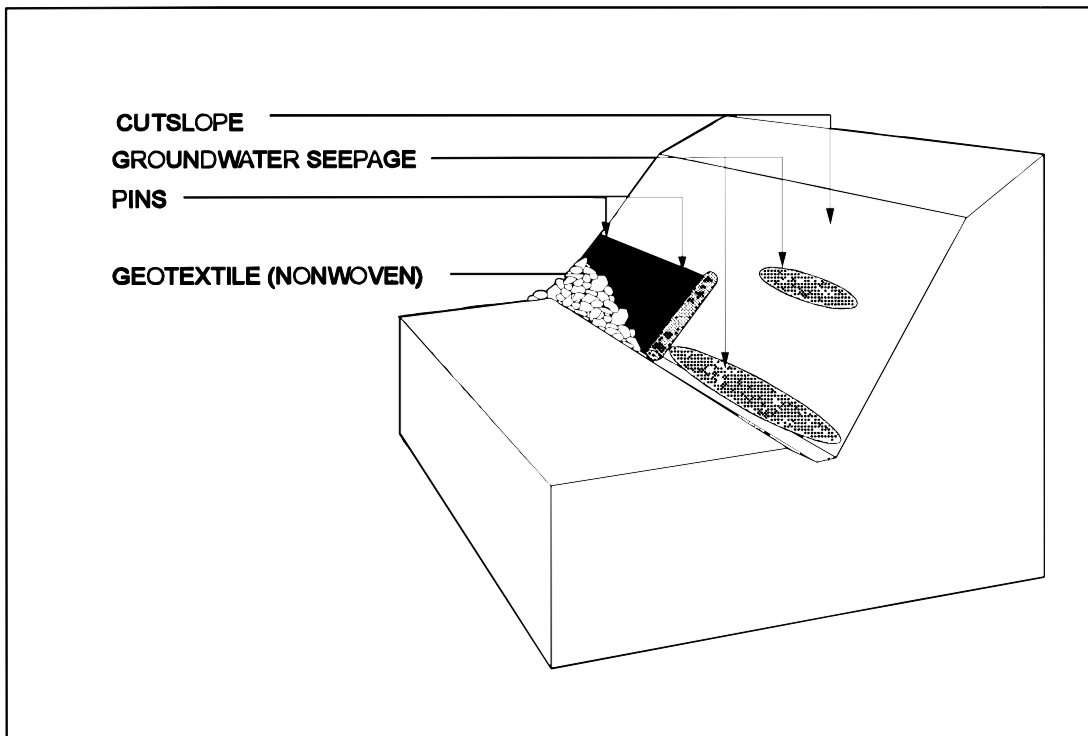


Figure 3. Arrangement of the geotextile

Material properties of the geotextile (index tests) are:

- Grab: 665 N @ 50%

- | | |
|-----------------|------------------------|
| | elongation |
| • Tear: | 265 N |
| • Puncture: | 420 N |
| • Burst: | 2240 kPa |
| • Permittivity: | 1.30 sec ⁻¹ |
| • AOS: | 0.212 mm |

Suggested “best practices” include:

- unroll the geotextile in short stages, to allow rock placement to follow closely that of the geotextile;
- secure the top of the geotextile with pins, to prevent slippage;
- ensure the geotextile is free of folds, tears and wrinkles. Place it loosely on the cutslope so that it conforms to the prepared surface of the soil. This ensures the geotextile does not bridge across undulations in the cutslope face, which may allow erosion to occur beneath it. Any surface water should be directed away from the edge of the slope;
- join the rolls with overlapped joints or stitched seams. Lap the upper geotextile over the lower geotextile at the joint. Unsewn joints should not extend more than 5 m to 10 m ahead of rock placement, in order to avoid separation of the overlap;
- in general, overlapping is appropriate for holding the geotextile in place during installation. Where the application requires the geotextile to resist tensile stresses, the seams should be sewn;
- in applications where the rock blanket is to fully cover a higher (>6m) or steeper (>45°) cutslope, give consideration to deploying the geotextile roll down the slope rather than across the slope;
- in contrast to the case of steady groundwater seepage, the geotextile may not be sufficiently permeable to allow unimpeded flow of water across it at locations where rapid and very concentrated flow of water occurs through, for example a buried channel in the soil. Special drainage provisions such as a slot drain may then be required beneath the geotextile to mitigate the potential for a localized washout.

SUMMARY REMARKS

Feedback over the years from projects in the forest sector of British Columbia suggests that geosynthetics are easy to install, offer cost and time savings, yield greater credibility with regulatory agencies and simplify construction in unstable soil. The current needs are to

ensure specification of the appropriate geosynthetic for the site conditions, and to follow best practices during installation.

ACKNOWLEDGEMENTS

“Basic Geosynthetics: A Guide to Best Practices” was developed for applications of geotextiles and geogrids to soil stabilization in resource engineering. The construction case reports were prepared with funding for site visits from Forest Renewal British Columbia.

REFERENCES

- AASHTO (1998). Geotextile specification for Highway Applications. American Association of State Highway and Transportation Officials, M 288 – 299.
- Berg, R.R., Allen, T.M. and Bell, J.R. (1998). Design procedures for reinforced soil walls – a historical International Conference on Geosynthetics, 25-29 March, 1998, Atlanta, Georgia, pp. 491-496.
- Fannin, R. J. (2000). Basic geosynthetics: a guide to best practices. Bitech Publishers Ltd., Richmond, B.C., 85p.
- Mohoney, J. (1994). Retaining wall design guide. U.S.F.S., Washington, D.C.
- Steward, J.E., Williamson, R. and Mohoney, J. (1977). Guidelines for use of fabrics in construction and maintenance of low-volume roads. U.S.F.S., Portland, Oregon.