AASHTO M288: DURABILITY CONSIDERATIONS IN STANDARD SPECIFICATION DOCUMENTS

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

ABSTRACT

Construction survivability is integral to the selection of a geosynthetic for all construction applications. In many routine applications, where there is no economic rationale for site specific testing, the criterion of construction survivability may be the sole basis for selection of the geosynthetic. Two case studies are reported, from applications in resource engineering, where geotextiles were used in access road construction and streambank stabilisation. The material properties are compared with the default recommendations of AASHTO M288 for highways engineering. Comparison suggests the AASHTO M288 document is suitable for these resource engineering works.

RÉSUMÉ

La serviabilité de construction est intégrale au choix d'un géosynthétique pour toutes les applications de construction. Dans beaucoup d'applications courantes, où il n'y a aucun raisonnement économique pour l'essai spécifique de site, le critère de serviabilité de construction peut être la base seule pour la sélection du géosynthétique. Deux études de cas sont rapportées, des applications dans l'ingénierie de ressource, où des géotextiles ont été employés dans la construction de voie d'accès et la stabilisation de pente de rivière. Les propriétés matérielles sont comparées aux recommandations de défaut d'AASHTO M288 pour génie d'autoroutes. La comparaison suggère que le document d'AASHTO M288 est convenable pour ces travaux d'ingénierie de ressource.

1. INTRODUCTION

Geosynthetics are increasingly used to stabilize soils in natural resources engineering applications. The applications date back nearly 30 years, and indeed, geosynthetics were first used in construction of geotextile reinforced walls supporting logging roads in 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.

A recent guide to “best practices” (Fannin, 2000) describes the selection, specification and installation of geosynthetics in natural resources engineering projects, from experience gained in forest engineering applications. 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.

In many routine highway applications, the basis for selection of a geotextile is that of a standard specification document, using material properties reported by the manufacturer. Following publication of AASHTO M288, a study was undertaken to verify its suitability for resource engineering applications. Two of ten cases studies are described, where forensic observations were made in order to assess the relative success of the application. In all cases, selection of the geotextile was made with sole reference to experience, and without recourse to a standard specification document. Results of those field observations are summarised, together with implications for general use of standard specification documents.

2. SPECIFICATION OF GEOSYNTHETICS

Properties used in the specification of geosynthetics, are established from index tests or from performance tests:

- 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 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 as it relates to soil retention for erosion control. Durability properties are used to quantify the endurance of the goesynthetic during and after construction.

Performance tests are typically used to assess mechanical and hydraulic properties for design parameters governing soil/geotextile interaction. They are site-specific properties, determined form specialist laboratory tests.

3. CONSTRUCTION SURVIVABILITY

Survivability is integral to the selection of a geosynthetic for all construction applications. In many routine applications, where there is no economic rationale for site specific testing, the criterion of construction survivability may be the sole basis for selection of the geosynthetic. These routine applications include:

- *Stabilisation requirements*, appropriate for subgrade soils that are saturated due to a high groundwater table or due to prolonged periods of wet weather, wherein the basic functions are separation and reinforcement, with a potential for filtration;
- *Separation requirements*, appropriate for subgrade soils that are unsaturated, where groundwater seepage through the geotextile is not a critical issue;
- *Subsurface drainage requirements*, appropriate for long-term movement of groundwater from a saturated subgrade into a subsurface drain system, wherein the basic function is primarily one of filtration, with a potential for drainage; and,
- *Permanent erosion control requirements*, appropriate for riprap stone overlying erodible subgrade soils, wherein the basic function is again filtration, with potential for separation.

Accordingly, construction survivability is integral to the standard specification documents, wherein the required material properties are defined with reference to index tests. The challenge, in routine applications, is to ensure that the geosynthetic possesses sufficient strength to survive the demands imposed by soil placement and compaction during the construction period. Indeed, these demands at the time of construction may represent the most severe loading conditions experienced by the geosynthetic throughout its service life.

Construction survivability, a matter of short-term durability, may be considered a complement to issues of long-term durability that may influence the material properties over the service life of the application. Aside from the potential for construction-induced damage, the primary mechanisms of degradation over the long term are oxidation for polypropylene and high density polyethylene geosynthetics, and hydrolysis for polyester geosynthetics.

Construction survivability ratings have been developed for geotextiles, such as those proposed by AASHTO for highway applications, which assign a low (L), moderate (M) or high (H) level of survivability to applications. The ratings take into account factors such as strength of the subgrade soil, the contact pressure exerted by equipment on the ground, and finished thickness of compacted soil cover above the geosynthetic. The ratings also establish a combination of factors, notably thin soil cover (<150 mm) on soft ground (CBR<1), giving rise to such potential for construction-induced damage that the use of geosynthetics is not recommended (NR). The intent, then, in a standard specification document, is to equate the level of construction survivability to a class of strength. This leads to the recognition of three different classes of strength, Class 1 being the strongest and Class 3 the weakest. In determining the physical properties of each strength class, a distinction is made between the less extensible woven geotextiles and relatively more extensible nonwoven geotextiles, based upon the elongation of test specimens observed at failure in the Grab Tensile Test (ASTM D 4632). Inspection of geotextile strength requirements (see Table 1) indicates Class 3 geotextiles have approximately 50% to 60% of the strength of the companion Class 1 geotextiles. Hence, a Class 1 geotextile is specified for more severe or harsh installation conditions where there is a greater potential for geotextile damage, and Classes 2 and 3 are specified for less severe conditions. Variations on this approach have been adopted by provincial highways agencies in Canada. With reference to the routine applications mentioned above, the default specification of geotextile requirements (AASHTO M288) is as follows:

- Stabilisation requirements: Class 1 geotextile;
- Separation requirements: Class 2 geotextile;
- Subsurface drainage requirements: Class 2 geotextile; and,
- Permanent Erosion Control requirements: Class 2 (woven monofilament geotextile) or Class 1 (all other geotextiles).

Table 1 - Geotextile Strength Requirements (after AASHTO M288)

			Geotextile Class					
			Class 1		Class 2		Class 3	
			Elongation		Elongation		Elongation	
	Test Methods	**Units**	**<50%**	**≥50%**	**<50%**	**≥50%**	**<50%**	**≥50%**
Grab Strength	ASTM D 4632	N	1400	900	1100	700	800	500
Sewn Seam Strength	ASTM D 4632	N	1260	810	990	630	720	450
Tear Strength	ASTM D 4533	N	500	350	400	250	300	180
Puncture Strength	ASTM D 4833	N	500	350	400	250	300	180
Burst Strength	ASTM D 3786	kPa	3500	1700	2700	1300	2100	950

It is important to note that the Engineer may specify a geotextile of lower strength than the default class, for example a Class 2 or 3 rather than a Class 1, based on considerations that include:

a) The Engineer has found the class of geotextile to have sufficient survivability based on field experience;
b) The Engineer has found the class of geotextile to have sufficient survivability based on laboratory testing and visual inspection of a geotextile sample removed from a field test section constructed under anticipated field conditions.

Two case studies are related that address the issue of sufficient survivability based on field experience, for routines application in resource engineering. Implications of the field experience are considered, for selection of geotextiles using standard specification documents. Each case study comprises a brief overview of the project, which describes the general conditions, soils, application and construction procedure. A companion summary of the geotextile addresses the type and material properties, with reference to AASHTO M288.

4. RESOURCE ENGINEERING CASE STUDIES

4.1 Case Study 1: Cutslope Stabilisation

General conditions

- 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.

Soils description

- Subgrade soil: a broadly-graded, very gravely sand, with a trace of silt.
- Rock blanket: angular blast rock, D50 = 0.6 m and D100 = 1.1 m.

Application

- Special provisions are required to prevent the development of an unstable, eroding cutslope. The approach used was to place a rock blanket along the cutslope. The seepage conditions require the geosynthetic provide coincident functions of separation and filtration. A needle-punched nonwoven geotextile was specified.

Construction procedure

- Unroll the lower geotextile along the slope, using the excavator bucket. Secure the upper portion manually with pins, as necessary, to prevent sliding during installation.
- Place rock directly on the lower geotextile and key it into the ditch. Commence at the toe of the slope, and move up the slope (see Figure 1).
- Construct the blanket using an excavator, preferably with a thumb attachment, to avoid dropping the rock. This promotes a good interlock between rocks and protects the geotextile against unnecessary damage.
- Unroll the upper geotextile along the slope. The two geotextiles should be joined so that the material laps a minimum of 500 mm.

- Unroll the geotextile in stages, to allow rock placement to follow closely that of the geotextile (see Figure 2).
- Complete placement of the rock.

Figure 1. Geotextile installation over seepage horizon

Figure 2. Unrolling the geotextile

Geosynthetics summary

- A needle-punched nonwoven geotexile was used in construction , for which material properties are reported in Table 2. The geotextile meets the separation and subsurface drainage requirements of AASHTO M288 (see Table 3 and Table 4, respectively), with the exception of the grab strength for the default Class 2 material (see Table 1).

Table 2. Material Properties

Property	Case Study 1	Case Study 2
Grab Strength	665 N @ 50% elongation	890 N @ 50% elongation
Tear Strength	265 N	360 N
Puncture Strength	420 N	580 N
Burst Strength	2240 kPa	2756 kPa
Permittivity	1.30 sec^{-1}	1.4 sec^{-1}
AOS	0.212 mm	0.150 mm

Table 3. Separation Geotextile Requirements (after AASHTO M288)

	Test Methods	Units	Requirements
Geotextile Class			Class 2
Permittivity	ASTM D 4491	sec^{-1}	0.02
Apparent Opening Size	ASTM D 4751	mm	0.60 max. avg. roll value
Ultraviolet Stability (Retained Strength)	ASTM D 4355	%	50% after 500 hrs of exposure

Table 4. Subsurface Drainage Geotextile Requirements (after AASHTO M288)

			Requirements Percent silt and clay (<0.075 mm)		
	Test Methods	Units	<15	15 to 50	>50
Geotextile Class				Class 2	
Permittivity	ASTM D 4491	sec^{-1}	0.5	0.2	0.1
Apparent Opening Size	ASTM D 4751	mm	0.43 max. avg. roll value	0.25 max. avg. roll value	0.22 max. avg. roll value
Ultraviolet Stability (Retained Strength)	ASTM D 4355	%	50% after 500 hrs of exposure		

Durability issues

- A site inspection, 1 year after completion of construction, indicated the rock blanket was performing well. There was no indication of adverse damage to the geotextile, based on forensic observations. Accordingly, the field experience associated with this site suggests there is a basis for relaxing the default Class 2 strength criteria in some cases.

4.2 Case Study 2: Channel Stabilisation

General conditions

- A section of stream channel is incised through a terrace of hard, over consolidated, locally thick glacio-lacustrine sediments. The soil is very erodible. Streamflow undercuts the steep sides of the gully. This action, together with weathering and groundwater seepage, leads to frequent spalling of surficial soils and periodic slope failures that introduce fine sediment into the stream. Channel stability was further compromised by a debris flow event that removed much of the natural stone armour that had accumulated in the channel. Water quality is a key issue in the watershed, which is a main supply to the regional water system. The unstable channel is one of several point sources that result, occasionally, in unacceptable turbidity levels at intakes for the water supply.

Soils description

- Subgrade soil: a broadly-graded, clayey silt of low plasticity.
- Riprap stone: angular blast rock, D100 = 1.0 m, D50 = 0.6 m.

Application

- Placement of the riprap stone directly on the very fine in-situ soil may result in excessive scour and washout of the rock. The geosynthetic provides coincident functions of separation and filtration. It allows unimpeded flow and rapid dissipation of water pressures, and prevents the migration of fines from the subgrade through large voids in the riprap. The intent was to facilitate the natural re-establishing of stream-born rock armour in the channel. A needle-punched nonwoven was specified.

Construction procedure

- Temporarily divert streamflow above the section of channel to an adjacent drainage, at the time of seasonal low flow.
- Clear the stream channel of large organic debris using a tracked excavator.
- Place two rolls of geotextile side-by-side to achieve the necessary coverage of the in-situ soils. Join the geotextile rolls with a 1.5 m overlap (see Figure 3).
- Advance the geotextiles a short distance along the channel, working upstream, before covering with riprap stone.
- Place the riprap stone without significant free-fall (drop height les than 0.3 m).

Figure 3. Stone placement

Geosynthetics summary

- A needle-punched nonwoven geotextile was used in construction , for which material properties are reported in Table 2. The geotextile meets the permanent erosion control requirements of AASHTO M288 (see Table 5), with the exception of the grab strength for the default Class 1 material (see Table 1), by a small amount.

Table 5. Permanent Erosion Control Geotextile Requirements (after AASHTO M288)

			Requirements		
			Percent silt and clay (<0.075 mm)		
	Test Methods	**Units**	**<15**	**15 to 50**	**>50**
Geotextile Class					
Woven Monofilament Geotextiles				Class 1	
All Other Geotextiles				Class 2	
Permittivity	ASTM D 4491	sec^{-1}	0.7	0.2	0.1
Apparent Opening Size	ASTM D 4751	mm	0.43 max. avg. roll value	0.25 max. avg. roll value	0.22 max. avg. roll value
Ultraviolet Stability (Retained Strength)	ASTM D 4355	%	50% after 500 hrs of exposure		

Durability issues

- A site inspection, 3 years after completion of construction, indicated the riprap stone was performing well (see Figure 4). There was no indication of adverse damage to the geotextile between the riprap stones on the streambank, which were large and yielded sizeable voids between them. In contrast, the geotextile in the streambed itself was very badly torn, likely by bedload transport during storm events. Nonetheless, the channel stabilisation has proven very successful, with significant reductions achieved in downstream turbidity levels. Accordingly, the field experience associated with this site suggests there is a basis for relaxing the default Class 1 strength criteria.

Figure 4. Incised channel with riprap stone (3 years after placement)

5. SUMMARY REMARKS

In using the AASHTO standard specification document, and with reference to issues of construction survivability the Engineer may specify a geotextile of lower strength than the default class, for example a Class 2 or 3 rather than a Class 1, based on considerations that include:

a) The Engineer has found the class of geotextile to have sufficient survivability based on field experience;
b) The Engineer has found the class of geotextile to have sufficient survivability based on laboratory testing and visual inspection of a geotextile sample removed from a field test section constructed under anticipated field conditions.

Forensic observations are reported for two routine applications of geosynthetics in resource engineering works, where geotextiles were selected without reference to AASHTO M288, and where a qualitative assessment of performance indicates the installation is functioning well. The field experience is supportive of sufficient survivability in cases where the geotextile strength does not fully meet the default strength class. Accordingly, the provision in AASHTO M288 to allow the Engineer to specify based on field experience is considered both prudent and reasonable.

6. ACKNOWLEDGEMENTS

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