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An Innovative Application for Nonwoven Geotextiles

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ABSTRACT: This paper presents a new technique of using Nonwoven Polypropylene Geotextile as opposed to the standard woven weed matting on the embankments for erosion and weed control applications. By incorporating nonwoven geotextile as an erosion and weed control material, soil erosion and vegetative detachment were greatly reduced. The geotextile provided an additional shear strength to the vegetative and soil structures, allowing large volumes of water to percolate into the ground, which resulted in the rapid growth of the vegetation.

At one site, some of the results were not acceptable due to the early break down of the geotextile. Tests were conducted to analyze the cause and concluded that the fabric must contain carbon black and sufficient UV inhibitor to perform well. The fabric can be engineered to last for a specific period say from 3 – 24 months.

Key words: Erosion, Weeds, Drainage, Stabilization and Aesthetically Pleasing Appearance

1 INTRODUCTION

New Zealand is a very young country with few inhabitants. Since 1910 did it have over one million people, and today just less than 4 million. Although it does not have the pressures of overpopulation, it nonetheless suffers the ill effects of over exploitation. The country is world renowned for its “greenery” natural beauty and healthy agricultural products. Its economy is based largely on the energy from the soil. Due to treacherous terrain and previous exploitation, soil erosion of the land has become a major problem.

Thousands of hectares of land have vegetation removed or are laid bare each year around the main cities in New Zealand for construction purposes. Scientists estimate the loss of soil in New Zealand, through erosion and transport by rivers to the sea at 400 million tons per year. It arises mainly from the 22 million hectares of cultivated land, averaging 18 ton per hectare or 10-20 times the rate of natural soil formation. Without protection measures, the transformation of this land can result in accelerated on site erosion and greatly increased sedimentation of waterways, estuaries and harbours.

In addition to the soil erosion, a major objective of landscape maintenance programs is the suppression or elimination of weeds. Owing to Auckland’s moist temperate climate, the city is often referred to as “the weed capital of the world”. Weeds are controlled in landscapes using cultivation, hand weeding, organic and inorganic mulches, herbicides and physical barriers (black plastic and geotextiles) and various combinations of these methods. Each method has advantages and disadvantages.

In New Zealand, various techniques are used for erosion control applications from top soiling, revegetation, temporary & permanent erosion control blankets to runoff diversion channels, contour drains, hard and soft armor materials. The majority of the weed control fabrics used are heavy-duty woven polypropylene fabrics over 100 gsm and they are superior to other ground covers available in the country.

In this paper a nonwoven polypropylene geotextile was used as a weed and erosion control fabric and was successful on most of the sites. The sites under consideration had mostly clay overlaying silty clay subsoil, which exacerbates the moisture problems. The fabric was laid and not covered with mulch but with predominantly smaller NZ native shrubs were planted at close intervals in order to cover the whole surface in 12 months time.

2 DESIGN

Based on the literature review and current applications, Permathene Ltd recommended 135 g/m² polypropylene nonwoven geotextile to be used for the erosion control and weed control application for the projects under review. Polypropylene is a very durable polymer commonly used in aggressive environments including automotive battery casings and fuel containers among other applications.

It was recommended to plant vegetation by making slits in the geotextile so that at a later stage it should provide the shade to the geotextile and reduce the UV light degradation. Due to the superior puncture and mullen burst strength, a 135 g/m² nonwoven geotextile is very resistant to the installation stresses.

2.1 *Location*

The two projects under review covered earthworks and some additional works for the following sites:

- New East Tamaki Arterial Route (ETCART) from Cavendish Dr. through to Orlando Dr. in Manukau city, New Zealand
- Slope Stabilization at Mayfair Retirement Village, Browns Bay, Northshore, New Zealand

2.2 *Geotextile material*

Syntex 401 polypropylene nonwoven geotextile manufactured by SI Corporation, USA

Syntex 401 Nonwoven Geotextile Specification

PROPERTY	TEST METHOD	TYPICAL[2] VALUES
Physical		
Mass per Unit Area	ASTM D5261 ISO9864	135g/m²
Thickness	ASTM D5199	1.2mm
Mechanical		
Wide Width Tensile Strength	ASTM D4595	9.0 kN/m
(Elongation @ Break)	BS 6906/1	(40%)
Grab Tensile Strength	ASTM D4632	555N
(Elongation @ Break)		(60%)
Mullen Burst	ASTM D3786	1650 kPa
Trapezoidal Tear	ASTM D4533	240 N
Hydraulic		
Pore Size (O_{95})	ASTMD 4751(Dry)	0.150mm
Permeability	ASTM D4491	190 l/m²/sec
Endurance		
UV Resistance (% retained @ 500 hours)	ASTM D4355	70%

NOTE:
[2] Values shown are in weaker principal direction. Typical indicates mean or average value of all test data.

3 INSTALLATION

The side slopes of the covered embankment were 2H:1V to 1H:1V. Initially all the existing unwanted plants were manually removed and vigorous weeds such as oxalis and couch were killed by spraying herbicide on the embankment prior to geotextile installation. All the rocks, clods and debris were also removed. The geotextile was laid over an area with existing plants. The fabric was arranged around plants and slits were cut for some of the plants to protrude. The fabric was placed in intimate contact with the base without wrinkles and folds. It was secured in place using 9 inch steel staples placed at approximately 0.5 m – 1.5 m intervals.

The geotextile was placed with the machine direction parallel to the length of the slope. The adjacent geotextile sheets were joined by overlapping 300 mm in all instances. Extreme care was taken during installation so as to avoid any damage to the geotextile.

4 TESTING

"Perhaps the single most important property of a geotextile is its tensile strength. Invariably all geotextile applications rely on this property either as the primary function (as in reinforcement applications) or as a secondary function (as in separation, filtration or drainage)" Koerner, 1994.

The samples were tested in accordance to ASTM D 4632 – 91 for breaking load (grab strength) and elongation (grab elongation) of geotextiles using the grab method. The testing was done in dry conditions at Permathene's material laboratory. A continually increasing load was applied longitudinally to the specimen and the test was carried to rupture. Values for the breaking load and elongation of the test specimen were obtained from the machine electronic scales. It is a useful quality control or acceptance test as it was desired to determine the "effective strength" of the fabric in use after the exposure to the UV radiation. Ten specimens each were taken in the machine and cross-machine direction respectively.

The ETCART project was installed in May - June 2000. The laboratory tests were conducted on samples retrieved from actual ETCART sites and recorded in Table 1. The results showed that about 37 % strength loss after 60 days of exposure, but the material was in tact and not broken down. The strength loss was seen and it was about 78 % in 13 months with no signage of breaking of the material. The area was partially covered with shrubs. This was quite convincing as NZ being a country prone to very strong UV, the results were satisfying. In summer, New Zealand typically receives around 50 % more UV than Southern Germany.

As seen from the Figure 1, the strength decreases @ 37 % in 2 months, 68 % in 6 months, 75 % in 9 months and finally 78 % in 13 months. After 9 months of exposure, the strength loss was only 3 % in 4 months, which concludes that there will be not much further loss of strength before the geotextile fully breaks down.

The tests conducted on samples retrieved from the Mayfair Village project site were of concern as shown in the Table 2. These samples were taken from the areas badly damaged / broken down where the soil was exposed. The installation for Mayfair project was done in October 2000. As seen from the figure 2, about 80 % strength loss after 60 days of exposure was observed and further 12 % strength loss in 90 days, thus a total loss of 92 % in 5 months and finally 93.5 % in 9 months. After 6 weeks of installation, it was noted that the material had broken down in most areas. The initial reasons discussed with the client's engineer were either the geotextile was tightly stretched in some areas or not being placed property on the ground or chemical attack. It was unusual for the 135 gsm fabric to deteriorate in such a short span as compared with the ETCART project.

In March 2001, we took the virgin sample of the geotextile and sprayed with isopropylamine liquid herbicide (Roundup) on the top. The tests were conducted on both the samples (Virgin and with roundup) and the results are shown in Table 3 and 4 respectively. As seen from the figure 3 and 4 respectively, the strength loss was 20.5 % for virgin geotextile as compared to 23.5 % for chemically treated geotextile after 4 weeks of installation on a open leveled ground in a fully exposed conditions.

After 4 months, the tests were again conducted and the strength loss was 32.5 % for virgin geotextiles versus 37 % for chemically treated geotextile. Hence it was concluded that the herbicide spray has got no appreciable affect on the geotextile. The chemical may have been sprayed just prior to installation or even after the installation of the geotextile but will not affect the performance.

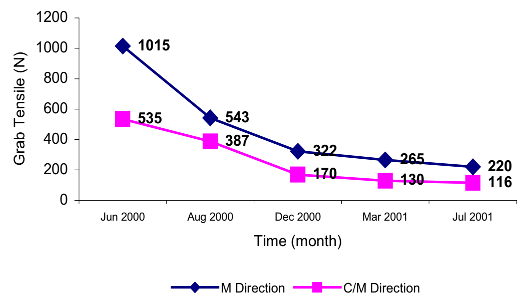

Figure 1. ETCART Site Grab Tensile Strength vs Time

Table 1. Grab Tensile Strength of the Geotextile at ETCART Site

Samples	Time	Average Grab Tensile Newton		Apparent Elongation Breaking Point (%)	
		Machine Direction	Cross Machine Direction	Machine Direction	Cross Machine Direction
Virgin	Jun 2000	1015	535	83	87
1^{st}	Aug 2000	543	387	72	61
2^{nd}	Dec 2000	322	170	58	53
3^{rd}	Mar 2001	265	130	49	49
4^{th}	Jul 2001	220	116	45	48

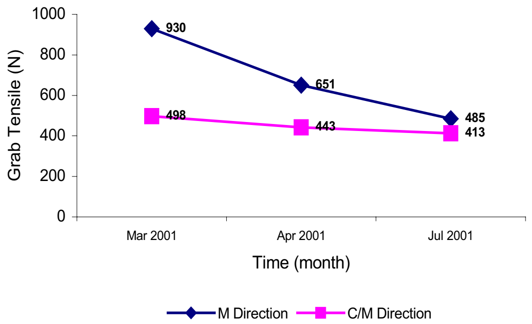

Figure 2. Mayfair Site Grab Tensile Strength vs Time

Table 2. Grab Tensile Strength of the Geotextile at Mayfair Site

Samples	Time	Average Grab Tensile Newton		Apparent Elongation Breaking Point (%)	
		Machine Direction	Cross Machine Direction	Machine Direction	Cross Machine Direction
Virgin	Oct 2000	887	74	481	71
1^{st}	Dec 2000	221	51	65	38
2^{nd}	Mar 2001	114	45	12	25
3^{rd}	Jul 2001	98	41	10	21

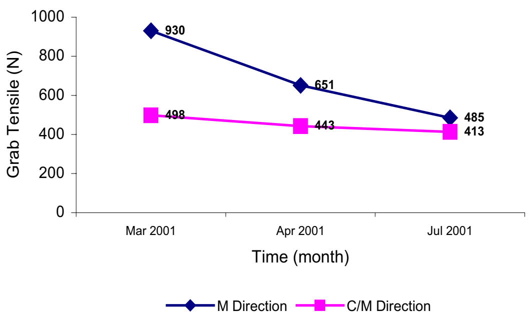

Figure 3. Grab Tensile Strength vs Time for Sample without Roundup Herbicide

Table 3. Grab Tensile Strength of Geotextile without Roundup Herbicide

Samples	Time	Average Grab Tensile Newton		Apparent Elongation Breaking Point (%)	
		Machine Direction	Cross Machine Direction	Machine Direction	Cross Machine Direction
Virgin	Mar 2001	930	498	81	79
1^{st}	Apr 2001	651	443	69	58
2^{nd}	Jul 2001	485	413	60	52

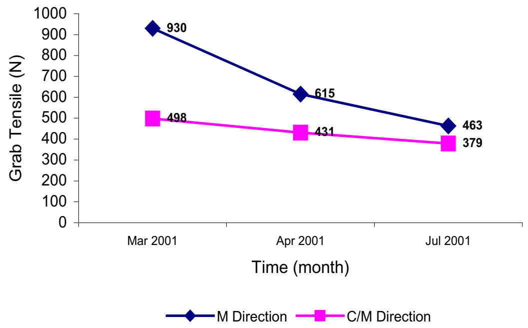

Figure 4. Grab Tensile Strength vs Time for Sample Sprayed with Roundup Herbicide

Table 4. Grab Tensile Strength of Geotextile with Roundup Herbicide

Samples	Time	Average Grab Tensile Newton		Apparent Elongation Breaking Point (%)	
		Machine Direction	Cross Machine Direction	Machine Direction	Cross Machine Direction
Virgin	Mar 2001	930	81	498	79
1^{st}	Apr 2001	615	66	431	57
2^{nd}	Jul 2001	463	62	379	51

On the other hand, the degraded samples from the Mayfair job taken in April 2001 were sent to the manufacturer's laboratory for the carbon black content testing adopting ASTM D4218 standards. The results are reported as under in Table 5.

Table 5. Mayfair Site Samples tested for Carbon Black content

Degraded Samples	Carbon Black (%)
Virgin	0.64%
1^{st}	2.80%
2^{nd}	2.83%
3^{rd}	1.20%
4^{th}	0.78%

The test sample was divided into 4 small samples. Samples 1 and 2 respectively had visual signs of soil contamination and the high test results shown in Table 5 reflect soil contamination. This was also the thickest part of the field sample where the soil locks into the interlocking fibers of the geotextile. Sample 4 showed a high degradation and there were no visible signs of contamination due to fewer fibers for soil to lock into. The results for this sample came very close to the standard control results. This indicated that there was a minimal amount of carbon black in the sample. Is this 100% conclusive? No, a further step was taken to trace back the carbon black test results on the fiber used to make this particular geotextile. It was produced with standard 5-denier off-black fiber. Two different fiber batches were blended to make this nonwoven product, which is a standard manufacturing operation. The average carbon black test results from the last two years on the 5-denier off-black fiber was calculated as 0.57%. It was also confirmed that the manufacturer has made no changes to the additive package or suppliers of carbon black nor has their suppliers made any changes.

Based on the above test results, it was concluded by the manufacturer that there was no deviation from the norm in processing and testing of the material as related to the carbon black content in the fiber made to produce this particular product.

Stable Embankment with Fully Grown Vegetation – ETCART Project

5 PERFORMANCE

NW Geotextile specified in the ETCART project served the following purpose:

- It controlled the weed growth naturally without the continuous use of chemicals and sprays. Thus, water stagnation was prevented, soil was not soured. Roots were protected from the spread of fungus and bacteria and water evaporation were reduced.
- It provided an erosion resistant barrier until the vegetation was established. Seedlings were planted through a slit in the fabric and the fabric was laid around the existing plants by making a slit and protruding each plant through it.
- The soil, geotextile and vegetation worked together to provide a more stable embankment than vegetation alone. Non-reinforced vegetated areas were more likely to have individual plants dislodged due to soil erosion than reinforced vegetated slopes. The vegetation in conjunction with the geotextile function as a single unit instead of individual plants.
- The nonwoven geotextile has a high co coefficient of friction and hence acted as a non-slippery drainage medium for the water to seep through the fabric, rather than ponding over the fabric. It was permeable and able to absorb water.
- The vegetation was established very fast as compared with site having standard woven matting.

Since it is known that polypropylene degrades during extended exposure to sunlight but this geotextile was produced with carbon black and other UV inhibitors to protect against degradation. These additives allow nonwoven polypropylene geotextiles to be exposed for a certain length of time.

On the Mayfair project, all the above objectives were achieved but in some areas, the soil was exposed within 6 – 8 weeks of the installation. In order to suppress the weeds in those particular areas, the herbicide was sprayed. The erosion problem was taken care of and the slopes were stabilized by using the geotextile.

It is becoming a standard practice to use nonwoven geotextile for weed and erosion control applications and extensive installations are going on along the motorways in this part of the world.

6 CONCLUSIONS

The ETCART project covered an area of approximately 22,000 m2 and the major advantages of using nonwoven geotextile were the low installation costs, easy handling of the fabric, aesthetically pleasing appearance and the ideal drainage performance. The native shrubs were planted making slits in the fabric in order to have a canopy faster. This was a new concept of using nonwoven geotextiles instead of standard woven ground cover fabrics and it was successful.

Upon final analysis of the Mayfair job and contrary to laboratory analysis, which indicated adequate carbon content, we concluded that the problem here was one of carbon dispersion. For adequate UV protection of an exposed fabric, it is imperative that carbon be dispersed evenly through out the polymer. The Mayfair job had uneven carbon dispersion and this resulted in an early break down of the fabric in some areas. The exposed areas were treated with herbicide, which have stopped the growth of the weeds in those areas. On the whole, the installation of the geotextile has prevented surface erosion during the shrubs establishment period and also assisted in the suppression of the weeds.

In conclusion, 135 g/m² nonwoven geotextile produced with carbon black and other UV inhibitors can be used as a weed and erosion control blankets. It is more cost effective and easier to handle than the standard woven ground cover fabrics. It has an ideal drainage performance and enhances vegetation. The vegetated slope looks aesthetically pleasing and provides a good ground cover. Finally, Polypropylene is not harmful to soil and becomes a part of the soil as degradation progresses.

7 ACKNOWLEDGMENT

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