Filtration and permeability of wick-drain jackets in short and long term performances

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ABSTRACT: The evolution of concepts about the technical properties of prefabricated drains jackets, for accelerated consolidation of soft clays, is discussed in this paper. An oral controversy with S. Hansbo and G.den Hoedt, in Stockolm in 1981 and researches from the Warsaw Agricultural University, about the advantages of paper or nonwoven polyester filtration jackets for soft clays are discussed. An special mix of nonwoven polyester and cotton and viscose filaments was developed in Brazil. The objective was to combine the qualities of both paper and polymeric nonwoven fabrics, in order to achieve rapid permeability, avoiding suction when mandrel is withdrawn and to obtain filtration without clogging in short and long periods. The performances of wick drains in straight and bent conditions are discussed.

1 INTRODUCTION

The first paragraph. The largest geodrain applications in Brazil were carried out in thick, soft, organic clay layers (peat). About 20 million meters of geodrains were placed through these soils. About 60% of these drains were manufactured in Brazil. Laboratory tests have demonstrated that the geodrains, under confining pressure, in straight or bent condition, present high values of discharge rate. Table 1 shows discharge rates over 400 cm3/sec, under a load of 100 KN/m2.

Table 1. ITA Junior Laboratory flow tests with geodrain 100x4(mm) ISO 12958/1999.

Description: Geocomposite for drainage					
Normal load 100 kPa - longitudinal					
Dh(cm)	Temperature	time	weight	Discharge rate	Q20
	(oC)	(s)	(g)	(cm^3/s)	(cm^3/s)
14,15	21	15	683,3	45,55	46,3
14,15	21	15	687,2	45,81	46,6
14,15	21	15	671,1	44,74	45,5
14,15					46,2
Normal load 188 kPa – longitudinal					
Dh(cm)	Temperature	time	weight	Discharge rate	Q20
	(oC)	(s)	(g)	(cm^3/s)	(cm^3/s)
13,7	21	30	959,4	31,98	32,5
13,7	21	30	961,3	32,04	32,6
13,7	21	30	963,3	32,11	32,7
13,7					32,6

The wickdrain is composed of a core and a surrounding jacket. The core must allow discharges in short and long periods (up to 1,000 days), with minimum discharge rates over 100 m3/ year, even when bent. For this, it is necessary that neither the jacket be clogged by fine particles of organic clay nor the particles that may pass through the pores, clog the flow channels of the core. In order that these requirements are met, there are criteria that relate apparent pore opening of jacket (AOS), with grain-size curves of embedding soil. Figure 1 shows families of curves of Santos City marine clays, furnished by MECASOLO for EMBRAPORT project (Remy 2007).

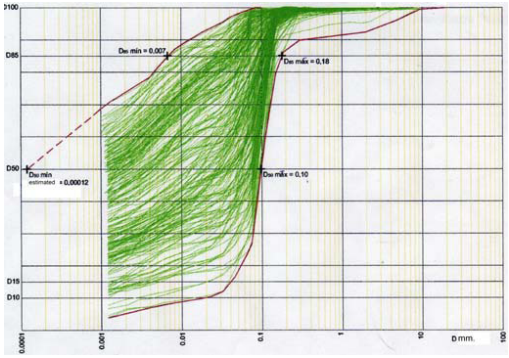

Figure 1. Grain-size distribution curves.

From the analysis of these curves it is possible to correlate pore opening of geodrain jackets with the

fine particles of clay, complying with recommendations that are similar to those of Bangkok (Holtz and Bergado) Laboratory tests of straight and bent geodrains in S. Carlos, USP, 2006 Tables 2 and 3 show discharges under pressure from geodrains both in straight and bent conditions.

Photos 1 and 2 (courtesy from Prof. B.S. Bueno)

Table 2. Results – Standard test.

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STRAIGHT DRAIN					
Tests		Volume	Time	Discharge rate	Discharge rate
		(L)	(Sec)	(L/Sec)	(m^3/year)
Sample 1	1	2	7,32	0,273	8616
	2	2	7,34	0,272	8593
	3	2	7,33	0,273	8605
Sample 2	1	2	8,87	0,225	7111
	2	2	8,95	0,223	7047
	3	2	8,80	0,227	7167
Sample 3	1	2	7,04	0,284	8959
	2	2	7,14	0,280	8834
	3	2	7,26	0,275	8688
Average values		2	7,78	0,259	8180

$O_{95}/D_{85} \leq 2 - 3$ and the retention ability of filter
$O_{50}/D_{50} \leq$ 10-12
(Indraratna et al. 2007)

Table 3. Results – Tests with bent drain.

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BENT DRAIN					
Tests		Volume	Time	Discharge rate	Discharge rate
		(L)	(Sec)	(L/Sec)	(m^3/year)
Sample 1	1	2	10,20	0,196	6184
	2	2	10,58	0,189	5961
	3	2	10,47	0,191	6024
Sample 2	1	2	13,27	0,151	4753
	2	2	13,17	0,152	4789
	3	2	12,95	0,154	4870
Sample 3	1	2	9,97	0,201	6326
	2	2	9,95	0,201	6339
	3	2	10,05	0,199	6276
Average values		2	11,18	0,182	5725

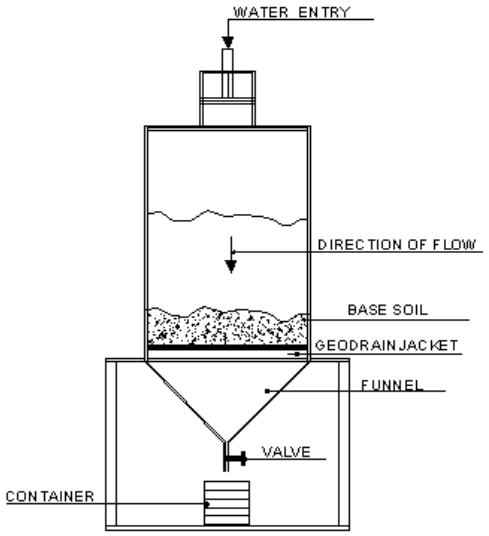

Figure 2. Apparatus for measurement of clogging reduction of permeability by fine particles of clay (ESTE Laboratory).

After checking the pore x particle relations, we will examine filtration with partial and acceptable clogging, by means of an apparatus made and adapted to control geodrains (Fig. 2). The requirements are recommended by several authors (Holtz 1989).

The criterion is Kg>2Ks, where Kg = permeability of the geotextile and Ks = permeability of the soil. Still remains the question brought up by S. Hansbo, during the 10th ICSMFE, in Stockholm. Paper jacket clogs less the flow channels of the core than geotextiles do (Koda et al. 1988) (Fig. 5).

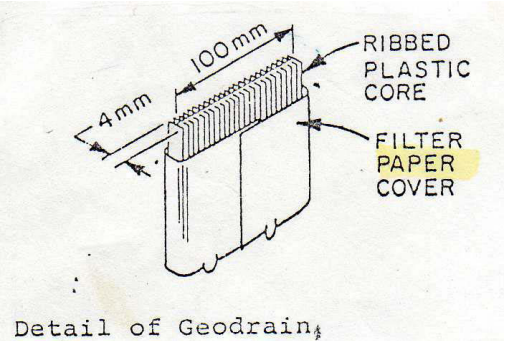

Figure 3. Geodrain detail (Burke 1981).

As it has been demonstrated later, during the 12 th ICSMFE, in Rio de Janeiro, (Holz et al. 1981), geotextile jackets maintain long term, pressurized drainage (> 500 days), better than paper jackets do.

Being aware of these data and controversies, since our visit to Geologic Zavod Liubliana in 1975, and the recommendations of Franc Vidic plus the experience of TERRAFIGO with drains of excellent performance, it was easy the search for the quality of the geodrain that takes into account the recommendations of these widely known authors, cited in the last 40 years, It was attempted to develop a jacket that had both the advantages of paper filter and of nonwoven geotextile.

The search for a drain with these characteristics has led us to a nonwoven jacket, with filaments of viscose, passed through a calender, under such pressure that gives to the nonwoven fabric, a texture close to that of the paper filter. Thus, even under the confining pressure, the discharge section area is not substantially reduced, as indicated by fig. 4.

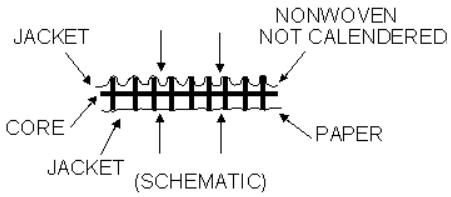

Figure 4. Geodrain cross-section.

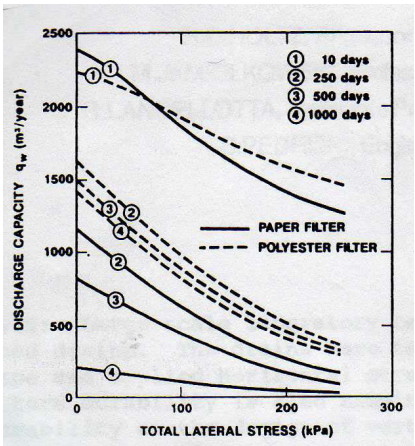

Figure 5 – Influence of time on discharge capacity of Geodrains (Koda et al. 1988).

As a subproduct from this search, another important characteristic of the jacket was found out: immediate permeability, before saturation. Thus, at the moment of the driving operation, gases contained in the organic clays arereleased. The effect is the dissipation of pore pressures at the exact instant the driving occurs. This fact avoids peaks of pore pressures Besides, it reduces the undesirable suction effects, at the moment the driving mandrel is being withdrawn.

As it is known, this suction effect aggravates sensitive clays smearing, around the geodrain. This explains the "mini-volcanoes", with bursts of gases and water, that are observed at the after-driving instant. Finally it should be emphasized that the geodrains may be manufactured from recycled materials, that reduces environmental pollution and collaborates with the reduction of global warming.

CONCLUSIONS

The geotextile that involves the band-shaped geodrain core, must allow the immediate release of gases enclosed in the voids of the marine clays of Brazil's coast. After that, particles smaller than 0,075 mm can pass, with the water flow, during the first 2 hours. After this period, a graded filter zone, about 10 mm thick, is formed around the drain.(G. den Hoedt).

The organization (or non-organization) of the nonwoven filaments, must retain particles from the first stage, maintaining the permeability at least greater than 2 to 3 times de permeability of soil, even after a partial and acceptable clogging, what can be measured with a special apparatus. (Fig. 2).

The nonwoven fabric, made from polyester filaments, with area unit weight between 75 and 85 gf/m2, is passed through a high-pressure calender and assumes a shape similar to that of paper filter (S.Hansbo, 1981) and has the advantage of polyester durability.

Addition of 15% to 20% of viscose to the polyester or polypropylene filaments, gives to the core, immediate permeability, before saturation, to avoid pore-pressure peaks, at the driving instant and suction phenomena at the instant of rapid mandrel withdrawl.

Finally, the geodrain performance depends on the way it was driven and embedded in the soil. The mandrel has minimum cross section (60cm2) and it is fixed by hydraulic pressure, with no vibration, with a small, flexible anchoring plate.

A small piece of flexible cable is used sometimes and this produces a smaller loss of the surrounding soil permeability by smearing, according to recommendations of Geologic Zavod Liubliana (1975), confirmed by Sandroni (2006).

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