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DETERMINATION OF TRANSMISSIVITY OF GEOTEXTILES. COMPARISON OF TESTS WITH SAMPLES UNCONFINED OR CONFINED IN SOIL

MESSUNG DER DURCHLÄSSIGKEIT VON GEOTEXTILIEN IN IHRER EBENE. VERGLEICHSTESTS MIT ODER OHNE BODENKONTAKT

MESURE DE LA TRANSMISSIVITE DES GEOTEXTILES. COMPARAISON DES ESSAIS AVEC ET SANS SOL

Five apparatus for measuring transmissivity of géotextiles with or without soil are discribed.

The results of transmissivity of woven and non noven geotextiles are given in relation with the mass by unit area, the machine or cross direction and the normal stress of geotextiles.

After analysis of results, it can be proposed an apparatus in which the normal stress of geotextile is exerted on a compressible product like a foam rubber.

1 - INTRODUCTION

It is now well known that geotextiles, and more particularly the needle-punched nonwoven - which have an open structure with a high void ratio, are able to drain water through their plane. KOERNER (1) has checked a number of applications in which the transmissivity of geotextiles is taken into account.

According to bibliography (1) apparatus for measuring transmissivity have a parallel or radial waterflow. If in the two cases, the Darcy's law is used to calculate the transmissivity, the radial flow requires an integration in order to take into account the geometry of the circular sample in which water penetrates from the center and flows out to the periphery. The linear apparatus have the best to permit a measurement of transmissivity in the machine and cross direction. This can be necessary for compound geotextiles used, for example, in the vertical drainage.

Whatever the apparatus used, the most important question is to know wether the measured transmissivity agrees with the one geotextile shows when it is in soil. The ideal solution would be to undertake the measurement with an apparatus in which the geotextile is in contact with soil. But such apparatus require long times for consolidation of soil under the wanted stress. Indeed, during the step of consolidation, the measurement may be strongly disturbed by the modification of hydraulic potentials along the sample and by flows coming from the soil.

The purpose of this study is to compare the results of transmissivity obtained with soil-test with that obtained with systems having different modes of application of the stress on the sample and to determine a laboratory method relatively simple and fast, the results of which are representative of the behaviour of geotextile in soil.

2 - APPARATUS

The apparatus used in this study are those available in our laboratory at the present time.

Geotextile Alone CEMAGREF Apparatus - Fig. 1 (2)

The sample, 20 cm wide, is put into a latex sleeve 0.3 mm thick. The stress is applied on a 30 cm length by an other membrane, inflated by air. The apparatus is supplied with disaerated water and the flow is measured with a flowmeter at a hydraulic gradient 1/3 under increasing stress. The loss of head without geotextile may be considered negligible and is withdrawn if necessary. The measurements are made 1 hour after the application of the stress.

CEMAGREF Soil-Geotextile Apparatus - Fig. 2 (2)

The principle of the apparatus is similar. The geotextile is put between two layers of compacted soil. The useful sizes of sample are 16 x 30 cm. A 2 cm gap is allowed between the sample and the side-walls in order to avoid the side effects. The soil is compacted with air-inflated membrane and the side walls are lubricated. For the comparative tests discribed below a test soil was used ; this is Limon d'Orly which is a clayey limon compacted at OPN + 2. In order to accelerate the consolidation, and to reduce disturbances which brings, the stress is applied two days before filling the geotextile. Like for the previous apparatus tests are made with disaerated water and with a gradient 1/3. Because of the consolidation effects, it is not possible to modify the applied stress after having made a test, except for highly transmissive products. Therefore , for comparative tests, we have tested geotextiles, in this apparatus, only with a 2 00 KPa stress. So, insurance is obtained to go beyond the pressure of préconsolidation

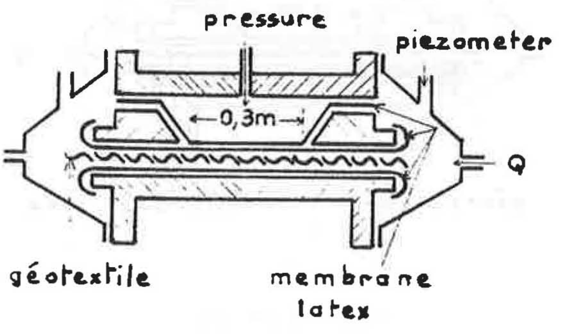


Fig. 1 - CEMAGREF. Geotextile alone Apparatus

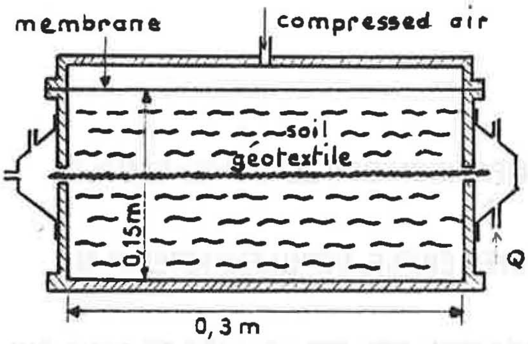


Fig. 2 - CEMAGREF - Soil Geotextile Apparatus

owing to compacting.

ITF Apparatus - Fig. 3

It is similar to the apparatus CEMAGREF Geotextile alone (Fig. 1). But a 4 mm thick foam rubber is put between the latex membrane and the metallic basis of the apparatus. This foam rubber, under the action of the compressive stress allows to match the exact shape of the geotextile surface and to avoid the eddy flows which could be generated on the geotextile surface.

IRIGM - P 200 - Apparatus - Fig. 4 (3 and 4)

A pile of N Samples the size of which are 20 x 20 cm, and put between two metallic plates. The stress on the pile is obtained by adjusting the gap between the plates.

IRIGM - Triaxial Cell. - Fig.5

This apparatus uses a triaxialcell in order to apply the stress of the geotextile. Special rectangular shoulders allow to put planar sample 15 cm wide and with a 15 cm useful length (20 cm entire heigth). Besides, shoulders allow the water alimentation of the sample and, by independent captors, the measurement of intersticial pressure. Chocks allow to well define the sample area under stress. The sample is separated from the cell medium by 6 mm thick latex membrane, tightly linked to the shoulders. The stress applied on the sample is transmitted, either directly on the membrane or by a pottery clay on each sides of the geotextile between the latter and the membrane. Characteristics of this clay are :

Porosity 46 % ; unit weight 14.6 KN/m^3 ; saturation ratio 1 ; undrained cohesion Cu = 16 KPa.

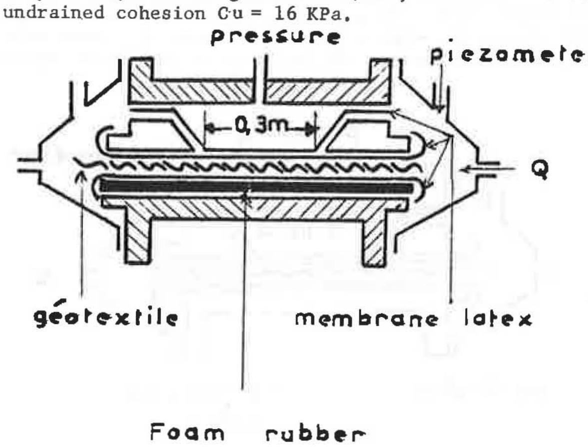


Fig. 3 - ITF Apparatus

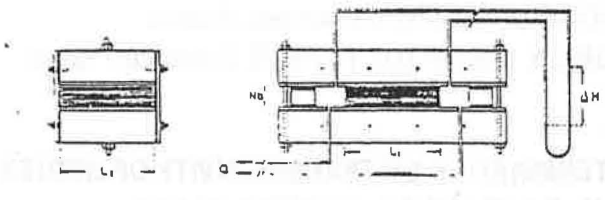


Fig. 4 - IRIGM - P 200

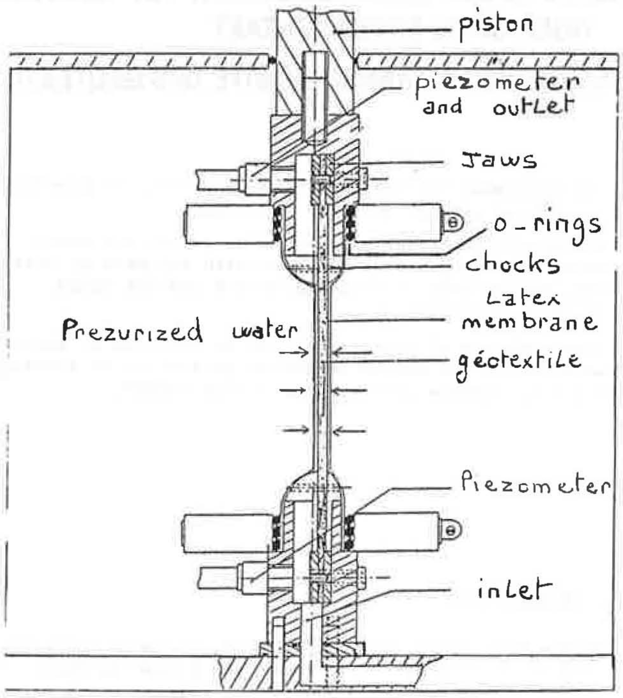


Fig. 5 - Triaxal Cell IRIGM

Therefore this cell allows transmissivity measurements with or without soil.

3 - RESULTS

The main characteristics of woven needle-punched nonwoven and thermobonded nonwoven, tested in this work are gathered in table 1.

3.1 - Influence of the mass by unit area on transmissivity obtained with the different apparatus.

Generally speaking, it can be noticed that transmissivity of needle-punched nonwovens (fg.6), and thermobonded fig. 7, like the one of woven fig. 8 is an increasing function of the mass by unit area.

For the needle-punched, the different apparatus give equivalent results. The lesser transmissivity values obtained with IRIGM Soil are assigned to the penetration of the very fine clay into the sample ; the clay induces a clogging which decreases the transmissivity, With thermobonded , CEMAGREF and IRIGM P 200 apparatus give higher values than those obtained with ITF apparatus and IRIGM triaxial Cell. This tendency is stronger, smaller the mass by unit area, i.e. when a low thickness of geotextile is able to promote preferental flows. The very low values obtained with soil are attributable to a clogging or to an insufficient soil consolidation.

With wovens, results give the same tendency, i.e. higher values of transmissivity for apparatus in which geotextiles are in contact with rigid plates.

From all these results, it appears that transmivities measured with ITF or triaxial cell IRIGM apparatus are the nearest of those obtained with soil. Therefore such apparatus are enjoined rather than apparatus in which geotextile is in contact with a rigid plate like IRIGIM P 200 or CEMAGREF apparatus.

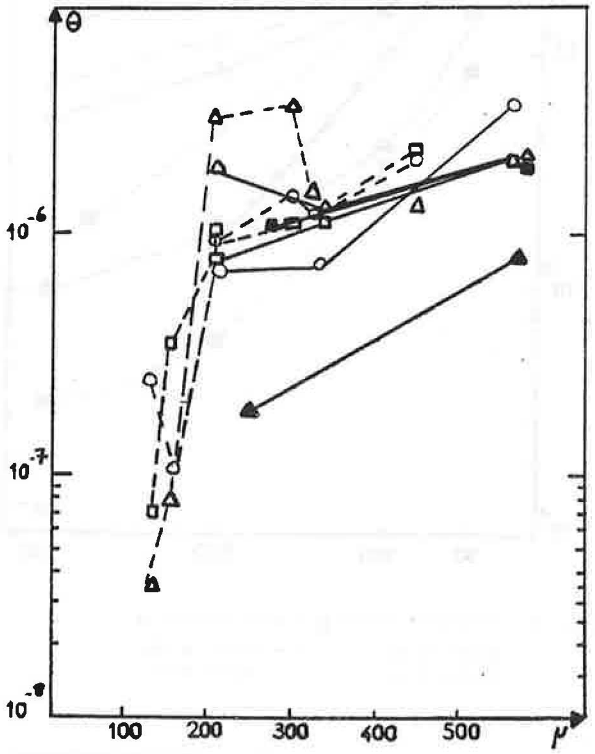


Fig. 6 - Needle-punched nonwoven transmissivity

CEMAGREF Geotextile Alone

ITF

Soil CEMAGREF

Bidim - - Trevira

IRIGM P 200

IRIGM Triaxial

Soil IRIGM Trixial

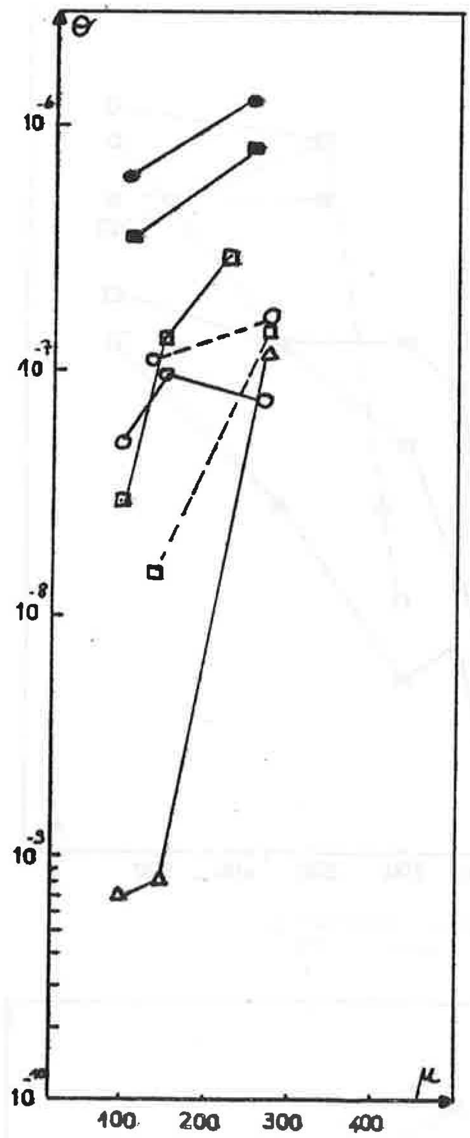


Fig. 7 - Thermobonded nonwoven transmissivity

- Terram - - Typar

3.2 - Transmissivity in relation with compression (Fig. 9)

Whatever geotextiles may be, one shows a decrease of transmissivity when the compression stress applied to the sample during test increases. The curves of fig. 10 show the evolution of transmissivity of Terram 700 in relation with stress on a pile in the P 200 and on a sample in the triaxial cell. They show risk to obtain erroneous values when piles are used. This risk is again more important for geotextiles which have a rough surface. It seems that such tests with needle-punched nonwovens do not give these same disadvantage.

3.3 - Transmissivity in relation with machine and cross directions

According to weave and texture of their machine and cross direction the woven geotextiles can have different configurations which can lead to different transmissivity for each direction. Curves of Fig. 11 give machine and cross direction transmissivity in relation with mass by unit area of geotextiles Robusta. The differences noted for the two directions are seen whatever the compression stress. Robusta 500 g (fig. 12) which have the same texture in either direction has the same transmissivity whereas Robusta 750 et 1 150 which have asymmetrical texture are characterised by different transmissivities in either direction.

3.4 - Transmissivity of a grid

Transmissivity tests with laminar and non laminar flow have been made on a grid an cell triaxial et P 200 IRIGIM. Measurements were performed either 24 hours or a week after putting sample in place. With P 200, transmissivity is independent of stress (10^{-3} $m^2/3$ in laminar flow and 2.10^{-4} m^2/s in non laminar flow). With the triaxial cell (Fig. 14), a decrease of transmissivity is observed with

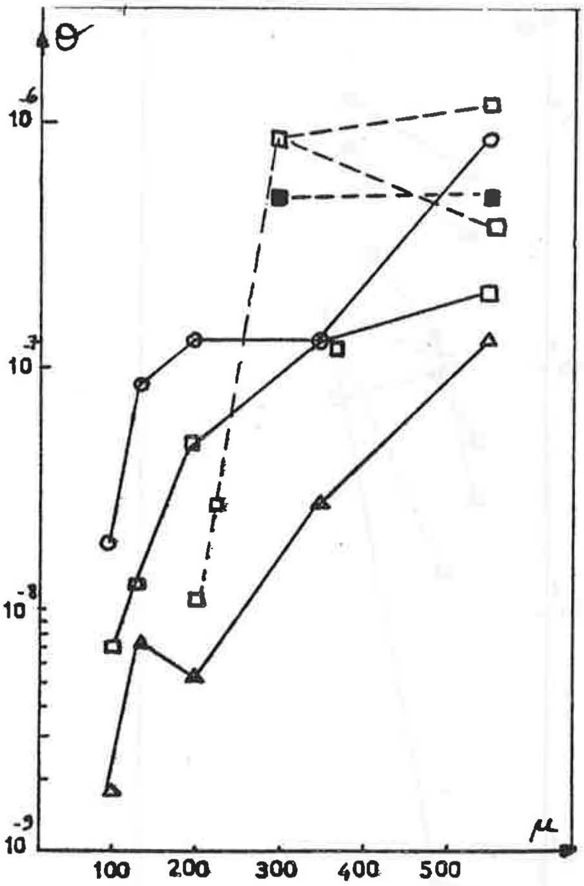


Fig. 8 - woven transmissivity
- amoco - - UCO

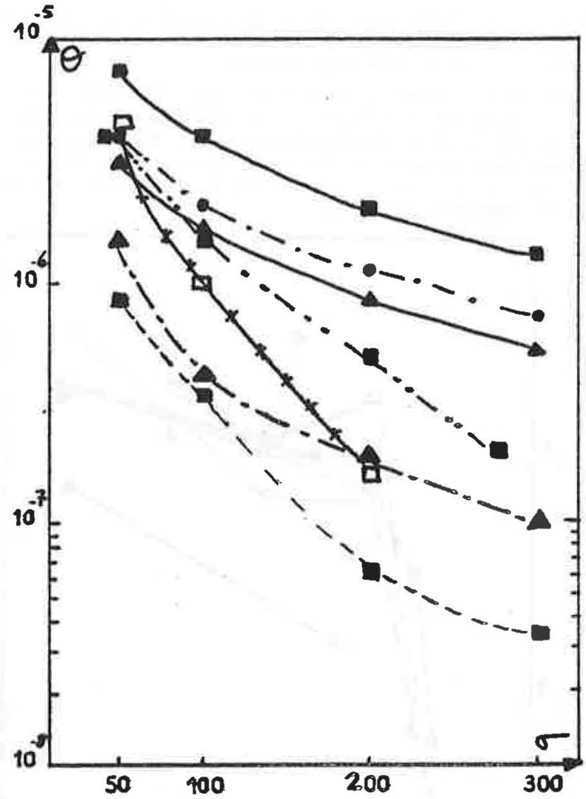


Fig. 9 - Transmissivity θ versus stress σ

- Bidim U 64 - - amoco 6 064
- Bidim U 34 - - UCO 4 4317

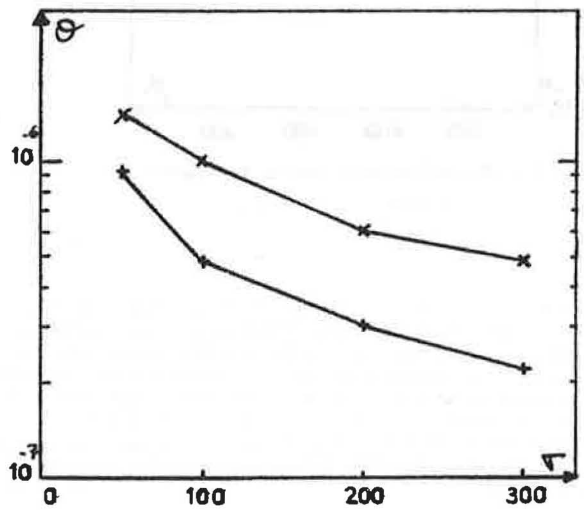


Fig.10 - Transmissivity of TERRAM 700

- Pile TRIGM P 200
- Triaxial Cell

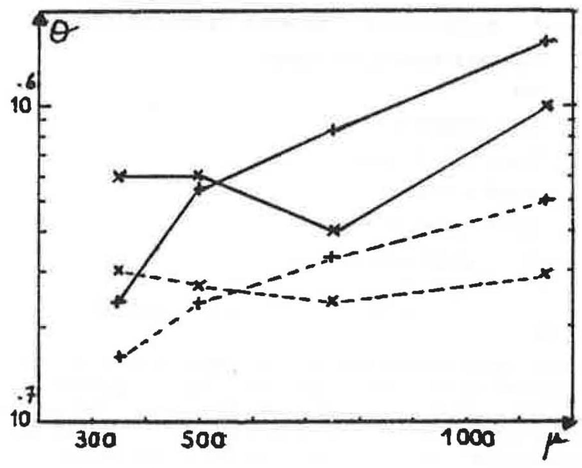


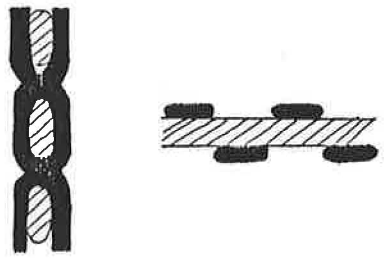
Fig. 11 - Transmissivity of Robusta

+ Warp X Weft

— σ = 200 DPa -- σ = 400 KPa

Géotextiles	Mass by unit area g/m²	Thickness (mm)		Transmissivity (m^2/s) i = 0,33, σ = 200 KPa		
		2 KPa	200 KPa	ITF	CEMAGREF	CEMAGREF/Sol
Bidim U24	210	2,1	0,7	$7{,}9\ 10^{-7}$	$7{,}9\ 10^{-7}$	$1{,}8\ 10^{-6}$
Bidim U44	337	3,1	1,2	$1{,}15\ 10^{-6}$	$6{,}6\ 10^{-7}$	$1{,}3\ 10^{-6}$
Bidim U64	558		2,12	$2\ 10^{-6}$	$3{,}4\ 10^{-6}$	$2\ 10^{-6}$
Trevira 13/130	136	1,4	0,5	$7\ 10^{-8}$	$2{,}54\ 10^{-7}$	$3{,}3\ 10^{-8}$
Trevira 13/150	155	1,6	0,6	$3{,}4\ 10^{-7}$	$1{,}05\ 10^{-7}$	$8\ 10^{-7}$
Trevira 11/200	215	2,4	0,64	$9{,}3\ 10^{-7}$	$9{,}2\ 10^{-7}$	$3\ 10^{-6}$
Trevira 11/270	296	3	0,89	$1{,}1\ 10^{-6}$	$1{,}4\ 10^{-6}$	$3{,}3\ 10^{-6}$
Trevira 11/300	323	3,2		$1{,}2\ 10^{-6}$	$1{,}2\ 10^{-6}$	$1{,}5\ 10^{-6}$
Trevira 11/420	452	3,8		$2{,}2\ 10^{-6}$	$2\ 10^{-6}$	$1{,}3\ 10^{-6}$
Terram 700	99	0	0,27	$3{,}3\ 10^{-8}$	$5\ 10^{-8}$	$7\ 10^{-10}$
Terram 1000	144	0	0,53	$1{,}35\ 10^{-7}$	$9{,}7\ 10^{-8}$	$7{,}9\ 10^{-10}$
Terram 2000	222	1,05	0,8	$3\ 10^{-7}$	$7{,}6\ 10^{-8}$	$1{,}3\ 10^{-7}$
Typar 136	132	0,48	0,3	$1{,}5\ 10^{-8}$	$1{,}1\ 10^{-7}$	
Typar 270	267	0,69	0,75	$1{,}7\ 10^{-7}$	$1{,}6\ 10^{-7}$	$1{,}2\ 10^{-7}$
AMOCO 6050	100	0,48	0,15	$6{,}8\ 10^{-9}$	$1{,}9\ 10^{-8}$	$1{,}7\ 10^{-9}$
AMOCO 6060	138	0,69	0,27	$2{,}5\ 10^{-8}$	$8{,}6\ 10^{-8}$	$7{,}2\ 10^{-9}$
AMOCO 6062	195	0,74	0,4	$5\ 10^{-8}$	$1{,}5\ 10^{-7}$	$5{,}8\ 10^{-9}$
AMOCO 6064	350	1,42	0,82	$1{,}4\ 10^{-7}$	$1{,}3\ 10^{-7}$	$2{,}8\ 10^{-7}$
AMOCO 6066	548	1,76	1	$2\ 10^{-7}$	$8{,}75\ 10^{-7}$	$1{,}33\ 10^{-7}$
UCO 44657	203	0,83		$1{,}1\ 10^{-8}$		
UCO 44631	222	0,84		$2{,}8\ 10^{-8}$		
UCO 44314	300	0,67		$3{,}1\ 10^{-7}$ (5,1)*		
UCO 84464	552	1		$1{,}2\ 10^{-6}$ (0,47)*		
UCO 44614	561	1,84		$3{,}7\ 10^{-7}$		

* Measurements with IRIGM triaxial cell



section warp direction   section weft direction

Fig.12 - Robusta 500

section warp direction   section weft direction

Fig. 13 - Robusta 750 et 1 150

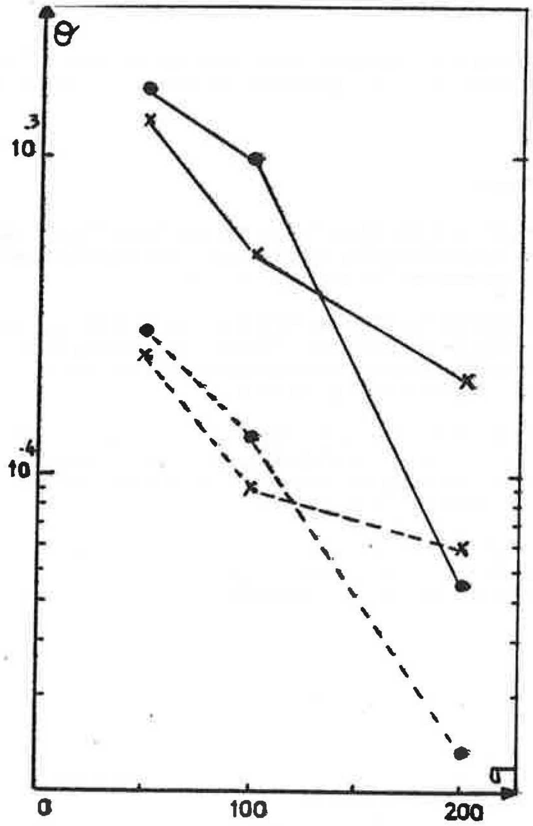


Fig. 14 - Transmissivity of a grid

x measured after 24 H - measured after a week
- laminar flow - - non laminar flow

increasing stress. Morever, a decrease of transmissivity when measurement is made either 24 hours or a week after putting sample in place is due to creep of the whole grid/membrane system. With a vertical drain often consisting of a grid and a thin thermobonded at its surface, a decrease of transmissivity will possibly arise from a creep of drain.

4 - CONCLUSIONS

From comparaison of transmissivity results of nonwoven and woven geotextiles obtained with apparatus used in this work the following results :

- the interest of measuring transmissivity in machine and cross direction
- the difficulty of tests with soil which are long to implement because of times required for consolidation and in which risk of clogging of geotextile by soil is not to be omitted
- the risks of preferential flow when geotextile is in contact with a rigid plate
- The good agreement of results obtained with soil with those obtained with apparatus like ITF or IRIGM triaxial cell.

An apparatus for measuring transmissivity should have a linear flow and be such that the compression stress of sample is applied on a compressive material like a foam rubber and not on a rigid plate. The ideal should be that the extended stress is uniform on both sides of the sample.

ITF apparatus or IRIGM triaxal cell can be useful for the description of an apparatus fitting to a standard method.

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