In-Soil Tension Strain Behaviour of Nonwoven Geotextiles

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ABSTRACT: The tension-strain behaviour of geotextiles, under uniform loading, is dependent on several factors, mostly on the intrinsic properties of geotextiles, on the overburden pressure imposed on the geotextiles by the soil confinement, on the interface soil-geotextile frictional behaviour, and on the properties of soil surrounding the geotextile. To evaluate the above mentioned factors, several tests have been developed in the last years.

The present paper illustrates the in-soil tensile test results of two nonwoven geotextiles using the apparatus illustrated by McGown et al. (1982) with two kind of sand as confinement. Finally a qualitative interpretation is proposed to explain the influence of confinement effect on the nonwoven tension-strain behaviour in terms of macrostructure of the products.

1. INTRODUCTION

In the last years, several tests were developed to evaluate the tension-strain behaviour of geotextiles under soil-confinement conditions [Ling et al., 1992]. These tests, reproducing fully or partially the predominant operational conditions of geotextiles in the field, are able to provide data that may be used in the design of soil structures.

From this viewpoint, the apparatus presented by McGown et al. (1982) symbolises a most successful test world-wide employed to measure the tensile properties of geotextiles under soil-confinement conditions.

This paper specifically deals with the evaluation of in-soil tension-strain behaviour of nonwoven geotextiles using the apparatus designed at Strathclyde University.

Two nonwoven geotextiles, a polyester needle-punched nonwoven (GTnw1) and a polyethylene-polypropylene thermobonded nonwoven (GTnw2) have been employed. The mass per unit area and the nominal thickness of these two geotextiles are given in Tab.1.

The selection of these materials is dependent from the following considerations:

(i) wovens, geogrids and geocomposites tension-strain behaviour is only little influenced by soil confinement;

(ii) nonwovens tension-strain behaviour is greatly influenced by soil confinement.

Several experimentation campaigns [Kabir, 1984, and Wilson-Fahmy et al., 1993] demonstrate the validity of the above mentioned assessments.

As soil confinement, two different kinds of sand, the Leighton Buzzard sand (LBs) and the Lago di Massaciuccoli sand (LMs), have been used as soil confinement. Both are "standard" sand respectively in UK and Italy. The grain size curves are shown in Fig. 1.

For each material 10 tests were performed, 5 employing as confinement the Leigthon Buzzard sand and 5 the Lago di Massaciuccoli sand. To allow a realistic comparison between the different kinds of confinement, same tests conducted in-soil conditions were also performed in in-isolation (INi) conditions.

The specimens used were 200 mm width and 100 mm gauge length [Cazzuffi et al., 1986]. All specimens were tested using a strain rate of 10%/min. A normal confining pressure of 100 kPa was used to evaluate the confinement effects.

Goetextile	**Bonding process**	**μ [g/m^2]**	**t_{GT} [mm]**
GTnw1	Needle-punched	143,9	1,45
GTnw2	Thermo-bonded	142,4	0,89

Tab. 1 Physical properties of geotextiles used

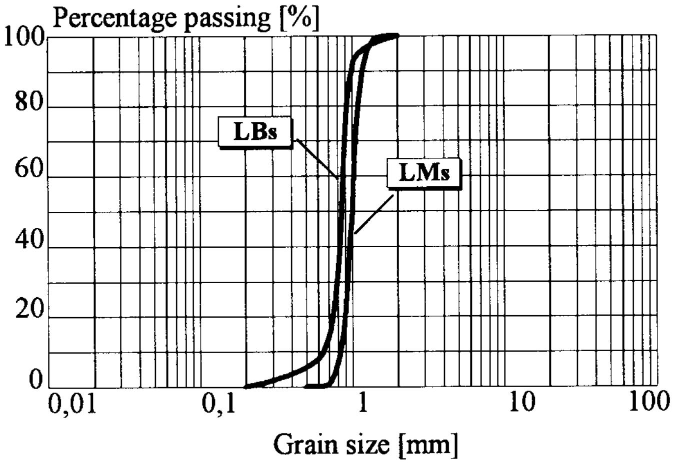

Fig.1 Grain size distribution curves of sands: Leighton Buzzard sand (LBs) and Lago di Massaciuccoli sand (LMs)

2. TEST EQUIPMENT

The test equipment used is composed by:

- a constant strain rate tensile load machine
- a confinement apparatus
- four load cells
- a data logger

The confinement apparatus is similar to that originally developed at Strathclyde University. However, some modifications are made to adjust the apparatus at the load machine.

3. ANALYSIS AND DISCUSSION OF RESULTS

The comparison beetwen in-soil and in-isolation tension-strain behaviour of needle-punched and thermobonded nonwovens is shown in Figg. 2-5.

From these figures it is possible to remark that the soil confinement gave a greater stiffness and strength for both geotextiles. The confinement effect on the two nonwovens produces an appreciable restriction of filaments mobility during the deformation process. The filaments mobility restriction may be due to both an "inclusion effect" of grains of the confinement sand into filaments web of nonwoven geotextile and a "pressure effect" of soil. The first effect hinds free alignment of filaments, whereas the second effect increases filaments friction.

Since the needle-punched nonwoven (GTnw1) has a relatively open structure, it allows, when subjected to confining pressure, to assume a more compact state and give rise to a higher stiffness and strength compared to the in-isolation conditions. In other terms the needle-punched structure allows an efficacious development both the inclusion effect and pressure effect on the restriction of filaments mobility.

Instead, as it can be see in Figg. 4-5, the confinement has little effect on the thermobonded nonwoven (GTnw2). This nonwoven has a compact and smooth structure, and therefore does not allow an efficacious development of both the inclusion and pressure effects. Consequently, the tension-strain relationship for the in-isolation conditions is similar to that of the in-soil conditions.

The effect of the kind of sand on the in-soil tension-strain behaviour is shown in Figg. 6-7. These figures indicate that both sands used for this experimentation lead practically to the same confinement effect. This fact can be explained by the very uniform grain size distribution of the two sands. A little different tension-strain behaviour noticeable derive probably from different grain shape of the sand and thus from different grade of interconnection between the confinement sand and the geotextile itself.

Finally, Tab. 2 give the tension at failure (T_f) and the initial tensile stiffness (J_i), in-soil and in-isolation conditions, for the geotextiles.

4. CONCLUSIONS

The test results substantiate the successful performance of the apparatus used. The results found are in good agreement with other studies recently published, see for example Ling et al. (1992), Wilson-Fahmy et al. (1993). The confinement effect modifies significantly the tension-strain behaviour of the two nonwoven geotextiles employed in this experimental study. In particular the confining pressure gave an increase in the initial stiffness and tension at failure of the needle-punched nonwoven. This effect is instead less evident for the thermobonded nonwoven geotextile.

The different effect of the same confinement on the two geotextiles is dependent from the different macrostructure of the two products.

Two different "standard" sands, characterised by a very uniform grain size distribution, lead practically to the same confinement effect on in-soil tension-strain behaviour of both nonwovens.

This fact opens an interesting prospective about the definition of a "standard" soil for the determination of in-soil tensile stress behaviour of geotextiles.

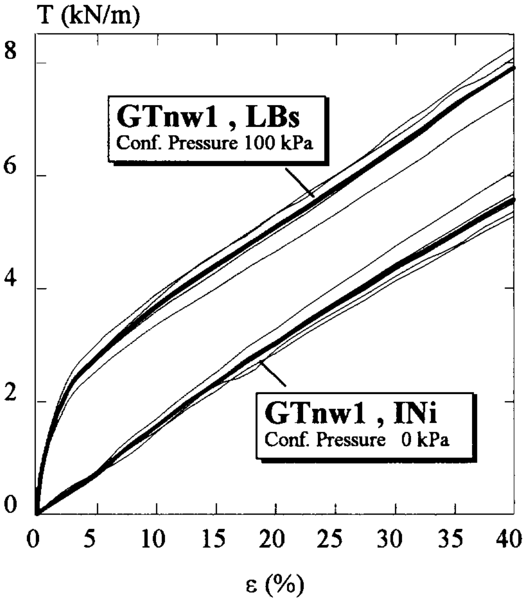

Fig.2 In-isolation & in-soil (LBs) tension-strain behaviour of needle-punched nonwoven (GTnw1)

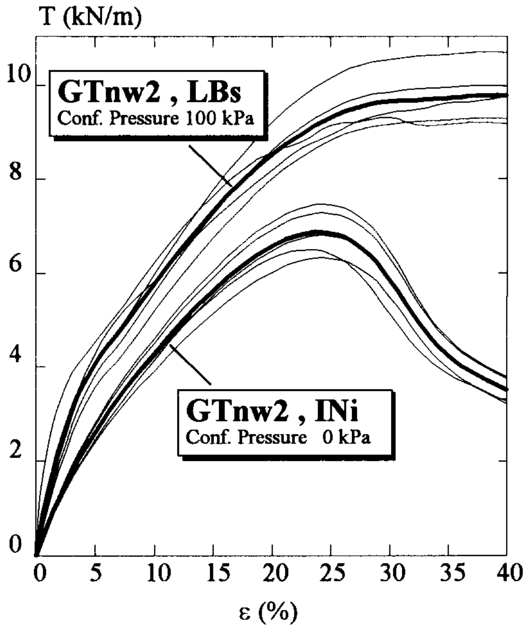

Fig.4 In-isolation & in-soil (LBs) tension-strain behaviour of thermobonded nonwoven (GTnw2).

	GTnw1			GTnw2		
	LBs	LMs	INi	LBs	LMs	INi
Tf [kN/m]	7,7	7,7	5,6	9,8	8,9	6,8
Ji [kN/m]	83	110	14	108	114	61

Tab.2 Tension at failure (T_f) and initial tensile stiffness (J_i), in-soil and in-isolation condition, for geotextiles.

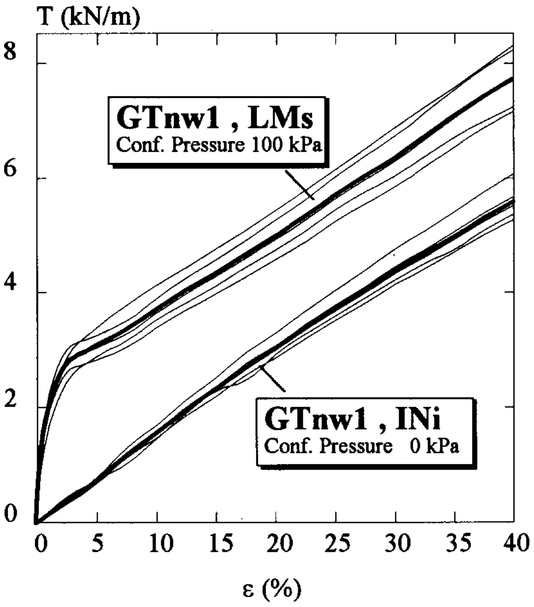

Fig.3 In-isolation & in-soil (LMs) tension-strain behaviour of needle-punched nonwoven (GTnw1).

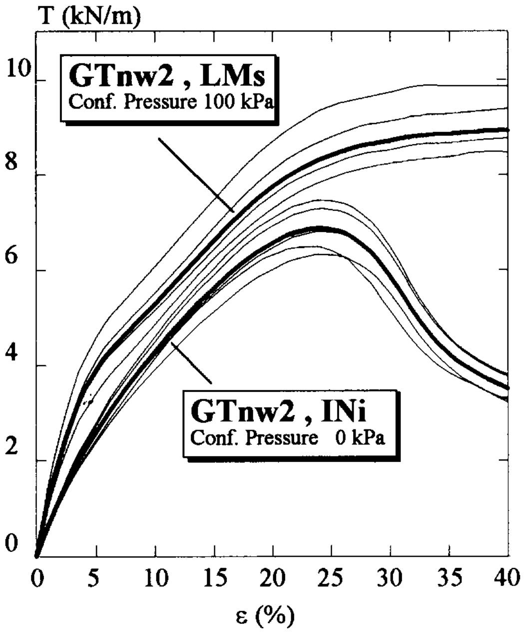

Fig.5 In-isolation & in-soil (LMs) tension-strain behaviour of thermobonded nonwoven (GTnw2).

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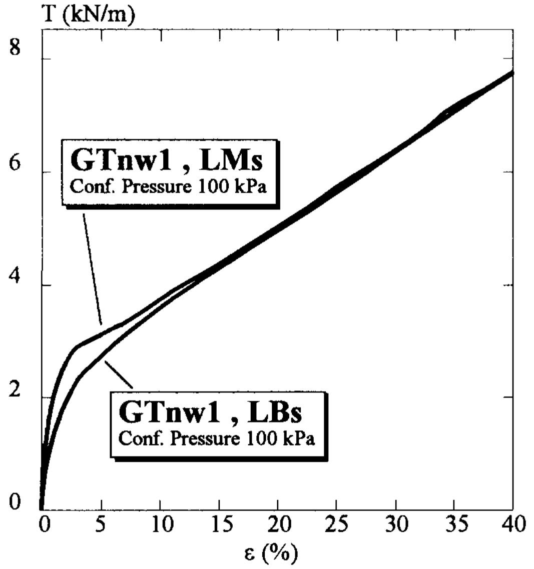

Fig.6 In-soil tension-strain behaviour of needle-punched nonwoven (GTnw1) in presence of the two different types of confinement sands.

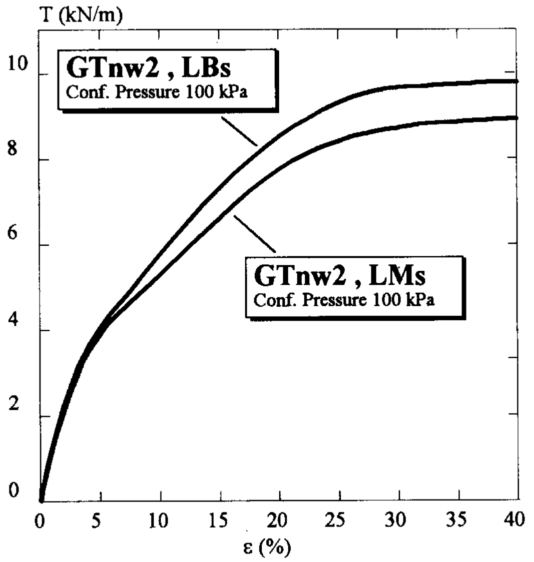

Fig.7 In-soil tension-strain behaviour of thermobonded nonwoven (GTnw2) in presence of the two different types of confinement sands.

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