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A study on the tensile properties of geotextiles confined in granule

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ABSTRACT: The confined extension testing of geosynthetics is essential for selecting and using reinforcement in the soil-reinforcement system. In this paper, a new method for testing tensile properties of geotextiles confined in granule is proposed. The tensile properties of confined in granule of two kinds of geotextiles (woven and needle punched nonwoven) are investigated through laboratory experiments and theoretical analysis. Compared with the tensile property in air, the stretch properties of the geotextiles confined in granular media are improved The improvement depends on the geometrical structure of the samples and processing parameters. Woven has few changes but not yet for needle-punched geotextiles. In addition, the parameters such as area density, the thickness and so on will influence the stretch effect of the geotextiles confined in granule. The normal stress and the kinds of granule are important factors for the experiment as well. The study focuses on the effects of the geometrical structure and the difference of tensile behaviour in detail between in air and in granule of the geotextile.

1 INTRODUCTION

It is not enough to consider the tensile properties of textile materials unconfined in air, especially for geotextiles being confined in soil or granule used in civil engineering. In fact, it was identified by numerous literatures (e.g., Myles 1987, Victor Elias 1998, Russell and Dobb 1999) that the mechanical properties of geotextile materials were greatly influenced by granule confining. If the confined effect of granule was ignored, it is very difficult to evaluate the mechanical properties of reinforced geotextiles exactly. And it will influence the calculation of stability and the costing of engineering for reinforced soil. In this paper the tensile behaviours were tested and analyzed of geotextiles confined in granule.

2 EXPERIMENT

2.1 *Materials*

Two kinds of geosynthetic materials were selected to test. The specification of five selected specimens presented in Table 1. The size of specimens used in the tests has a length of 200 mm and a width of 50 mm.

Table 1. Summary of specimens.

No.	Mass per unit area (g/m^2)	Thick-ness (mm)	Density*** (g/m^3) ($\times 10^5$)	Warp density (/10 cm)	Filling density (/10 cm)
N190*	190	0.8	2.375		
N230*	230	1.0	2.3		
N200*	200	0.80	2.5		
W1**	284	0.82	3.463	61	51
W2**	220	0.60	3.667	62	52

*Needle-punched nonwoven, materials are PET/PP (50/50);
**Slit-film woven (1000Denier), materials are PP (100%);
***Mass per unit volume.

2.2 *Methods*

Confined granular media selected are uniform disperse vegetable nutty seeds which have 2 mm average diameter. The specimens in testing length were covered up with granule materials, and they were confined by applied normal stress during extension process. Each set of test consisted of unconfined in air and confined extension tests. It should be pointed that test methods of the specimen referred to relatively standards (i.e., ASTM D 4595-86).

According to experiment principle, Instron 4206 was utilized to measure the tension load and elongation. The confinement box containing spring press device was designed as shown in Fig. 1.

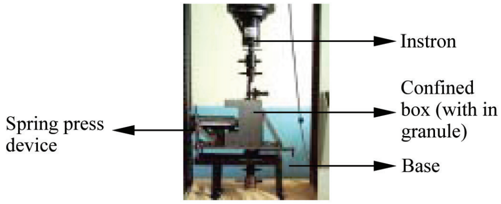


Figure 1. Confined extension machine.

Each of the five specimens was confined within granule under different normal stresses range from 0 KPa to 34.5 KPa. That is P0, P1, P2, P3 denoted the confined pressure is 0 Kpa, 11.5 Kpa, 23 Kpa, 34.5 Kpa, respectively. And each of specimens tested three times under every pressure level. The pressure is 0 that is inisolation tensile tests unconfined by granule in laboratory. The stretch rate of specimen is 100 mm/min.

The load-extension curve of each specimen was measured continuously.

3 RESULTS AND DISSCUSSION

3.1 *The effects of structures on tensile behaviourof geotextile being confined in granule*

The results of the confined extension test are analyzed in this section in terms of load-elongation curves for different confining pressure.

Obviously, confinement improves the tensile property of needle-punched nonwoven geotextiles (as shown in Fig. 2) significantly. The peak strength, the secant modulus at peak and initial tangent modulus of needle-punched nonwoven increased with increasing of confining pressure. However, the rate of elongation at peak decreased. Compared with extension in air (P0), the breakage strength of needle-punched specimen N190 improves 19.3%, the elongation decreases 10.4%, the secant modulus at peak improves 137.8% and initial tangent increased 384.0% when confining pressure increased 34.5 KPa.

However, it is not obvious for woven specimens (as shown in Fig. 3~4). The load-elongation curves of woven samples have basic superposition whether in air or in granule under different confining pressure, that is, the influence of confining with granule is not evident for woven samples.

Comparing to tension load of specimen in different pressure at the same strain rate is presented in Fig. 5-6. Tension load increased with normal stress increasing

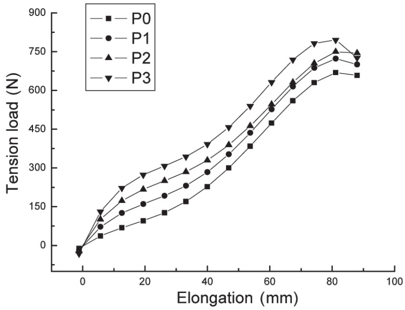


Figure 2. Tensile load versus elongation response for N190 under different pressure.

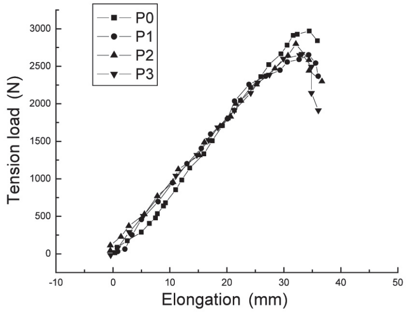


Figure 3. Tensile load versus elongation response for W1 (warp direction) under different pressure.

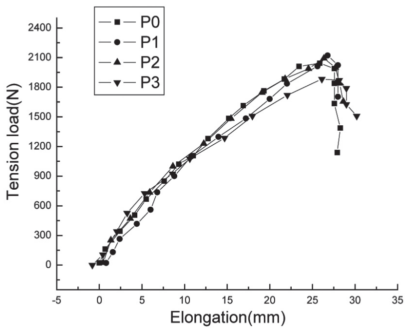


Figure 4. Tensile load versus elongation response for W1 (weft direction) under different pressure.

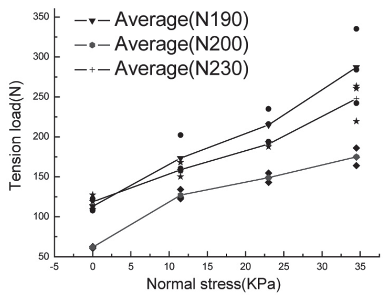


Figure 5. Tension load versus normal stress response for needle-punched specimens at same strain (10%).

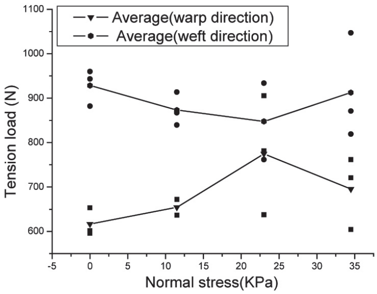
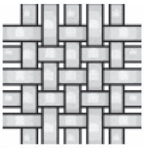


Figure 6. Tension load versus normal stress response for woven specimens W2 at same strain (5%).

for nonwoven specimens, that is, it is needed to increase tensile strength for specimen at the same strain as being confined. Corresponding to un-confinement, the increased strength used to overcome interface frictional resistance. Woven specimens have no similar laws. The tensile strength has no evident changes for producing same strain with the increasing of normal confining pressure.

Confinement of granule has less influence for woven specimens. This is due to needle-punched nonwoven and woven having completely different geometry structure(as shown Fig. 7). And both stiffness have great differences. Accordingly, the behaviour of two kinds of specimen is different for being confining pressure.

(a) Needle punched nonwoven.



(b) Slit-film woven.

Figure 7. Structure of samples.

A fibre web of needle-punched nonwovens in which the fibres follow devious entangled paths as illustrated in Fig. 7(a). As fibrous aggregation, individual fibres are assumed to move from side to side across the web and from top to bottom through the web. As being processing technology needled-punched samples possessed compressibility and built up in three dimensions.

If the nonwoven sample is now put under tension in air, the fibres will try to straighten, but it will be impeded by the entanglement. If the extent of entanglement is sufficient, then the fibres will become effectively gripped by the pressure of their neighbours and formed a self-locking structure. Outer confining load build up the transverse acting as being confined in granule. And the aggregation of fibres became more compacted.

Compare to extension in air, the frictional resistance within nonwoven samples increased at the same tension load. Further more, the greater the normal stress applied, the smaller the open size among the fibres, and so the internal friction force increased, the tensile resistance increased the stiffness modulus of specimen.

Both of the warp yarn and weft yarn of woven samples are slit-film flat thread (as shown in Fig. 7(b)). The single crimp fibre is not existed in fabrics. It has high stiffness and we can regard them as two-dimensional structure. The flat filament endures load for itself during extension. It is not compressed in transverse along by the longitudinal direction. And that the change caused by the adjustment of interspaces between the warp and weft is very limited during extension Because of its higher stiffness and less elongation, the internal frictional resistance has less change than that of needle-punched samples under exterior confining pressure, and the shear resistance rapidly reached maximum. The elongation along by the sample length correlated with tensile deformation modulus. It is concluded that the interface shear resistance can be regarded approximately fixed value with the stiffness increasing because of less elongation of reinforcement. The value depended on interface normal stress and friction coefficient.

3.2 *The effects of volume density on tensile behaviour of geotextile confined in granule*

Required frictional resistance to produce same tensile deformation under the same normal stress is different for three nonwoven samples, which is various with their volume density (mass per unit volume). The greater the mass per unit volume, the less the tensile strength under confining pressure (as shown Fig. 8).

Figure 8 shows N200 has lower tensile strength and higher deformation because of its great volume density compare to N190 and N230 whether in air or in 35.4Kpa.

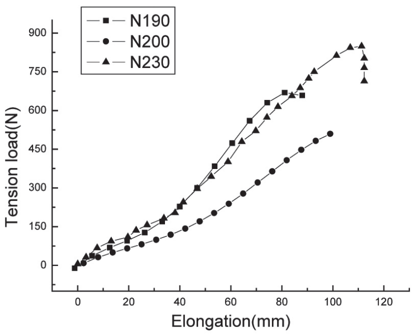
The effect on volume density for woven specimen is illustrated in Fig. 9. W1 has higher tensile strength and lower modulus compare to W2 because of its less volume density.

Obviously, the tensile strength increased with decreasing of volume density under the same confined pressure whether woven or not nonwoven specimens.

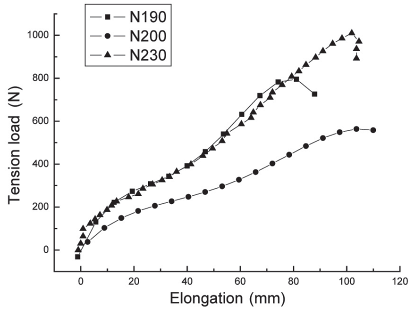
4 CONCLUSIONS

In this paper, the tensile properties of geotextiles both confined in granule and unconfined in air were investigated based on extension tests. The proposed method utilizing Instron tester and auxiliary load device is convenient and rapid.

The tensile behaviour of geotextile is different with its texture and extensibility. Accordingly, it has different response to normal pressure confined in granule. The greater the extensibility, the greater the



(a) The load-extension curve in air.



(b) The load-extension curve in granule under 34.5 KPa.

Figure 8. The effect on volume density for nonwoven.

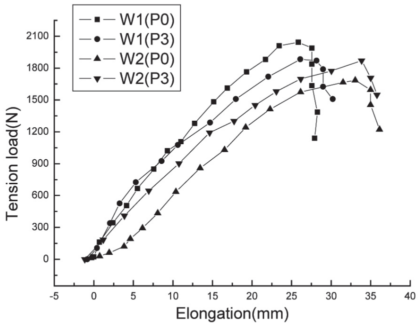


Figure 9. The effect on volume density for W1 (warp direction).

influence by confining pressure in granule. That is why confinement significantly improves the tensile property of needle-punched nonwoven but not yet for woven.

The greater the normal pressure applied, the greater the required tensile force at the same deformation for needle-punched specimens. As noted above, it is not for woven samples. The influence is extremely slight for woven samples confined in granule.

Whether nonwoven or woven, the greater the volume density of samples, the less the tensile strength and initial modulus under confining pressure.

Since reinforced geotextile usually is applied in soil engineering, it is true that the confining pressure from soil will influence the tensile behaviour of reinforcement. Thus it is necessary to evaluate exactly the tensile property of geotextile in terms of the confining extension test. It is not suitable for using tensile index tested in air for needle-punched nonwoven, which possessed less stiffness and greater deformation. Otherwise, the property of geotextile will be underestimated. As a result, the costing of engineering is higher.

REFERENCES

ASTM D4595-86. "Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method".

Elias, V. (1998). "Development of Products for Confined Extension/Creep Testing of Geosynthetics for Highway Applications", Report for FHWA.

Myles, B. (1987). "A Review of Existing Geotextile Tension Testing Methods", Geotextile Testing and the Design Engineer, Joseph E. Fluet.

Russell, S.J. and Dobb, M.G. (1999). "Instrumental Measurement of Strain in Nonwoven Geotextile Fabrics", Journal of Textile Institute, Part 1, No. 4, pp. 580-585.