Geosynthetics: Applications, Design and Construction, De Groot, Den Hoedt & Termaat (eds)
© 1996 Balkema, Rotterdam. ISBN 90 5410 836 3

Experimental study on geotextile tube dehydration method of dredged soil

Hiroshi Miki & Tetsuya Yamada
Ministry of Construction, Ibaraki, Japan

Isamu Takahashi
Mitsubishi Co., Ltd, Tokyo, Japan

Hiroshi Kokubo
Penta-Ocean Co., Ltd, Tokyo, Japan

Tohru Sasaki
Obayashi Co., Ltd, Tokyo, Japan

Abstract : The disposal of soil dredged from the bottom of rivers etc. has recently become a serious problem in the metropolitan areas. The geotextile tube dehydration method is a method of promoting the dehydration of soft dredged soil with high water content by filling a geotextile tube with the soil, and using the dehydrated soil as banking material or reclamation material by piling up such geotextile tubes. A research was conducted in order to study the stability of geotextile tube dehydrated soil when piled up. Rupture test for the external force and full scale experiments of large tubes were carried out in this research program. In addition a numerical model was devised to investigate the stability of geotextile tube dehydrated soil , and the results of the numerical analysis were compared with experiment results for the verification of numerical model applicability.

In this paper, we also report on effective examples of geotextile tube dehydration usage : one by using the tubes of dehydrated dam sediment to restore a collapsed slope and another by using dredged soil dehydrated in revetment of naturally diverse river improvement method.

1. Introduction

The geotextile tube dehydration method is a construction method used to speed up the dehydration of soil with a high moisture content by packing it in permeable tubes . The tensile strength of the tubes is used to allow piling up the geotextile tubes.

In this research project, to study ways of piling up geotextile tube dehydrated soil , firstly the external rupture test was carried out . And secondly a numerical model was devised to find the cross section shape, tensile strength, etc. of the tubes when they are piled up. And based on these results , a field test of large tubes piled up to form an embankment was carried out.

We also report on two examples of using the geotextile tube dehydration method: one where dehydrated dam sediment has been used to restore a degraded slope, and another where dehydrated dredged soil in tubes has been used as naturally diverse river revetments to restore nature.

Research and development of this method has been conducted by P.W.R.I(Public Works Research Institute) in collaboration with 36 private enterprises as one of the General Technology Development Projects conducted by the Ministry of Construction under the policy known as Development of Technologies for Recycling Construction By-products(1992-1996).

2. Features and Uses of the Geotextile Tube Dehydration Method

Past research on the geotextile tube dehydration method has demonstrated the following features [1),2)].

(1) It is relatively easy to insert the cohesive soil in the tubes because cohesive soil is fluid.
(2) The reinforcing effect of the geotextiles can be expected in embankments built by piling up geotextile tube dehydrated soil.
(3) Because the tubes can be made to any size, the time for the self-weight consolidation of soil can be adjusted by choosing the appropriate size of the tube.
(4) The density of the suspended solids in the moisture drained from the soil falls to low levels in a short time.
(5) The dehydrated soil packed in the tube is good for the vegetation.

In view of these features, this method is applicable to the construction of levees and naturally diverse river revetments and to the reconstruction of collapsed slopes.

3. Studies of the Piling Up of Geotextile Tube Dehydrated Soil

3.1 *Rupture Test for the External Force*

(1) Outline of the Test

As shown in Figure 3-1, the geotextile dehydrated soil was ruptured with external pressure, and the pore water pressure and the tensile strength of the geotextile were measured.

(2)Test Method

A small woven tube and a medium size tube were filled with cohesive soil (See Table 3-1), and the tubes were ruptured with a circular loading plate.

During this procedure, measurements were made of the loading force, the amount of displacement, the internal pressure of the tube, and the cross-section shape. And to investigate the effects of the cohesion, the rupture test was performed again after a hardening agent had been blended with the soil. Table 3-2 shows the experiment cases.

And based on earlier research [3),4)], the standards expressed by formula [1] were found to be appropriate for judging that a tube is full, so the injection was controlled by formula [1].

$$Hlimit = \frac{2Bo}{5.25} \quad [1]$$

Hlimit: Limit height for injection
2Bo: Circumference

(3) Test Results

Figures 3-2 through 3-5 show the relationships between the load force and the amount of the displacement and between the former and the pore water pressure for the small and medium size tubes.

1) Results of experiment on small tube

Figure 3-2 shows that when cohesion is expected, bearing capacity is generated by cohesion to resist the external force acting on the tube. When there was cohesion there was a tendency for loading force to rise rapidly against the amount of the displacement before the loading force reached the bearing capacity.

According to Figure 3-3, in the case of a high cohesion, the pore water pressure is very small immediately after the start of loading. This is because the load pressure is

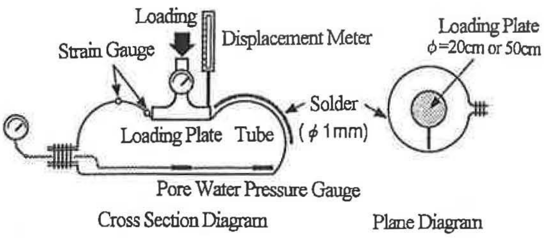

Figure 3-1 Schematic Diagram of the Test

Table 3-1. Physical Properties of Kasumigaura Cohesive Soil

Density of Soil Particles kg/m³	Grain Size Distribution: Clay %	Silt %	Sand %	Liquid Limit W_L(%)	Plastic Limit W_P (%)	Ignition Loss L_i(%)
2.509×10^3	84.2	15.1	0.7	232.5	55.8	21.1

Table 3-2. Experiment Cases

Tube	Cloth of Tube	Experiment Conditions	Cohesion of Clay in Tube
Small size	Woven cloth(T-150)	Diameter of Tube: 50cm	0.00kPa
	Thichness:0.25mm	Height at center: 19cm	2.94
	Tensile Strength 51 KN/m	Dimeter of Loding Plate: 20cm	8.82
	Permeability:1.0×10⁻⁴ m/s	Speed of Loding: 2mm/sec	
Mdium size	Woven cloth(T-200)	Diameter of Tube: 180cm	0.00kPa
	Thichness:0.35mm	Height at center: 70-75cm	2.94
	Tensile strength: 72 KN/m	Dimeter of Loding Plate: 50cm	7.84
	Permeability:1.5×10⁻⁵ m/s	Speed of Loding: 10mm/sec	

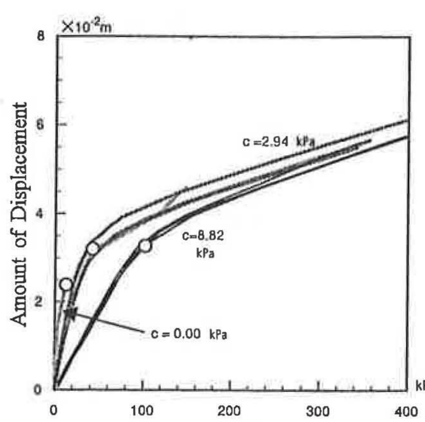

Figure 3-2. Amount of Displacement-Loading Force Relationship for the Small Tubes

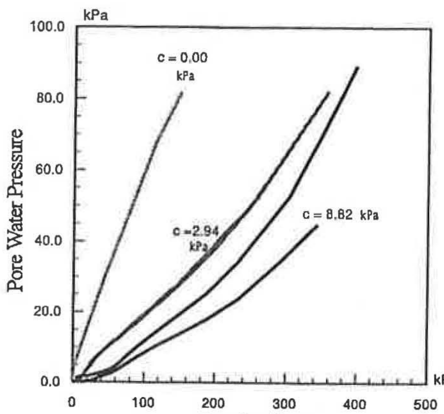

Figure 3-3. Pore Water Pressure-Loading Force Relationship for the Small Tubes

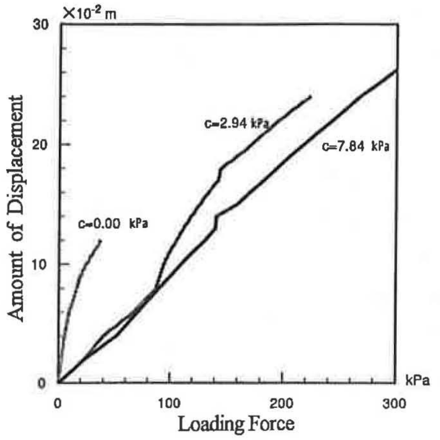

Figure 3-4. Amount of Displacement -Loading Force Relationship for the Medium Size Tubes

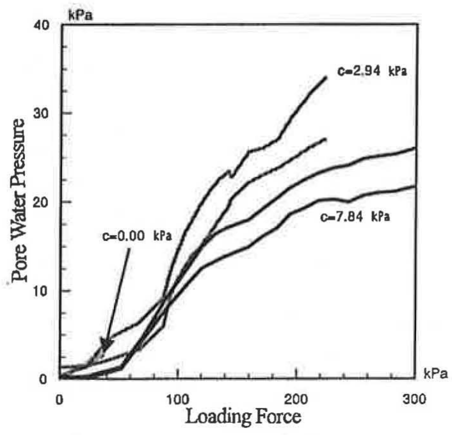

Figure 3-5. Pore Water Pressure-Loading Force Relationship for the Medium Size Tube

sustained by the cohesive content. When the load pressure exceeds a certain value, the pore water pressure increases in proportion to the load pressure.

2)Results of experiment on medium size tube

Figure 3-4 shows that in case of the medium size tube, the loading force rose against the same amount of displacement when there was cohesion, but the boundary was not as clearly discernible as in the case of the small tube.

According to Figure 3-5, in the case of a high cohesion, the pore-water pressure is relatively small immediately after the start of loading, and when the loading pressure exceeds a certain value, it increases in a straight line. This tendency agrees with results of the experiment on the small tube.

3.2 Creation of the Numerical Model

(1) Purpose

In order to study the stability of the geotextile tube dehydrated soil to be piled up, a numerical model was proposed to assess the cross section shape, tensile strength, etc. of the tubes. The results of the model study were compared with those of the rupture test on the medium size tube and the applicability of the method was evaluated.

(2) The Assumptions of the Numerical Model

Based on the test results , an axisymmetric model as shown in Figure 3-6 was employed. The following assumptions were introduced in this numerical model.

(a) The total volume of the tube is assumed to be constant. And it is also assumed that the shape around the loaded area is part of an arc.

(b) The extension of the tube caused by deformation is expressed by the following formula.

$$dL = \frac{T}{E}L$$

E : Modulus of Elasticity
L : Circumference of the tube cross-section
T : Tensile force acting on the tubes

(c) The following relations are obtained by balancing the top loading acting on the tubes , tensile force, and the pore water pressure of the cohesive soil.

$$\pi(B/2)^2 \cdot P = \pi(B/2)^2 \cdot u + \pi BT \cdot \cos\theta + N_c \cdot c \cdot \pi(B/2)^2$$

$$T = r \cdot u$$

r : Radius of the circular part u : Pore water pressure
B : Loading width P : Loading pressure
θ : Angle of the tensile force directions to the vertical direction

and according to the results of Rupture test. the calculation conditions were decided,as shown in Table 3-3.

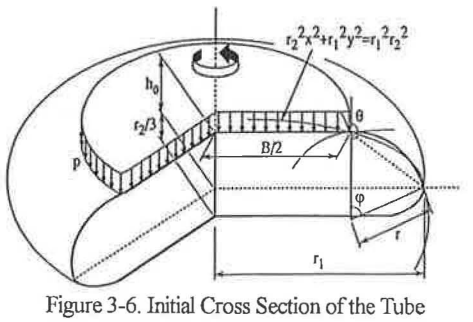

Figure 3-6. Initial Cross Section of the Tube

Table 3-3. Calculation Conditions

Cohesion	(kPa)	0	2.94	7.84
Elliptic Minor Axis Diameter	r1(cm)	90		
Elliptic Minor Axis Diameter	r2(cm)	54		58
Loading Width	B/2(cm)	25		
Initial Tube Height	ho+r2/3(cm)	70		75
Modulus of Elasticity	kN/m	490		

(3) Application to the Rupture Test of the Medium Size Tube

(a) Amount of Displacement - Loading Force Relationship

Figure 3-7 shows the relationship of the loading force with the amount of displacement. The calculation results agree well with the test results. But it is also shown that in the case of the numerical model, the tube is not deformed until the loading force reaches the bearing capacity produced by the soil's cohesion, while in the case of the testing, the tube is deformed from the initial stage of the loading.

(b) Loading Force - Pore Water Pressure Relationship