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RETROFITTING SHEAR STABILITY AND FIXING CLAY SOILS IN FARM CONDUITS BY GEOTEXTILES

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Shear tests which conducted in the soil mechanics laboratory to determine the effects of polymer materials (geotextiles) on shear strength of reinforced clay in conduits. It was found that setting geotextile sheets in 60 degrees to the plane of failure increases shear strength to a maximum of 25% than that with an unreinforced clay.
Keywords: Reinforced clay, shear strength, uniaxial shear test, geotextile, farm conduits

INTRODUCTION

Generally, in adequate strength of soil and movement of soil particles by water flow cause low tensile strength of soil materials. One of the modern methods in strengthening soils is utilizing polymer materials. There are several technical- economical and marketing reasons for development of polymer materials (especially geotextiles) (Saxena, 2004). These reasons are; a) being manufactured in a factory under quality control procedures assuring constant and controllable quality, b) polymer materials can be installed rapidly, c) polymer materials can generally be installed in difficult environment conditions, d) their light weight and small volume results in easier and less expensive transport, e) polymer materials are generally cost- effective as compared to natural or traditional man-made materials. Generally, geotextiles are from family of geosynthetics. Geosynthetics are textiles or some polymer material that their main properties are stability against deterioration factors which exist in soils or water (Geosynthetic Research Institute, 2007). Geotextiles are commonly divided in to two groups: a) Woven b) Non-woven (Scuero, 2004).Non-woven geotextiles are used to the address of reinforcement in research experiments. When geotextiles are employed as reinforcement the major properties are Young's modulus, tensile strength and strain in failure point (Xenaki, 2001). Because of the sloping of the roof and the presence of a drainage system, the hydrostatic head acting on the polymer materials is in all conditions minimum (Ling *et al*., 2004). In conclusion, the main concern when using a polymer material in roofing is the perfect welding of adjoining sheets and extension of placing (Noorzad, 2000). Due to having holes, water coming from the inside of the structure (seepage), or migrating towards the core in conduits from the surrounding can be drained and pore water pressure would not be produced). Drainage capability assures that the liner is protected from uplifts, and that soil stability is improved by the rehabilitation and drainage occurs in the gap provided behind the liner would be facilitated by installation of synthetic materials providing transmissivity.

MATERIALS AND METHODS

The extension of setting geotextile is on the base of following Columb formula.

$$\tau = c + tg\ \varphi$$

Where τ = shear strength of soil
c = cohesive strength of soil
φ = angle of internal friction of soil

According to the idea of the most designers, the best extension for placing reinforcements is in extension of major principal strain. In this research study, it is emphasized on special extension for placing reinforcement in clay that would increase the adhesive property (Hibbeller, 2008; Mardookhpour, 2003; Zhen, 2001). Generally, the best extension for placing geotextile in clay is the extension of principle strain in soil. In this case according to Columb formula the maximum shear strength in soil is obtained theoretically. For determining the best extension of placing geotextile in clay soils, some experiments have been done in soil mechanics laboratory (Mardookhpour, 2003; Obret, 1996).

RESULTS AND DISCUSSION

Experimental study on reinforced clay by non-woven geotextile (50 k N/m tensile strength)

According to the results of experiments if geotextile applied in 60 degree to horizontal failure plane, the maximum shear strength is provided in clay soils (Mardookhpour, 2003). Utilizing uniaxial shear test, for a sample of clay characteristics of D_{50}= 0.002 mm and maximum dry density γ_d = 1.8 g/cm^3, subjected to equal effective loads , reinforced by a thin layer of geotextile with 50 kN/m tensile strength, has been presented in Table 1-6.

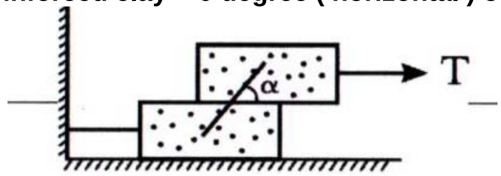
Table 1. Uniaxial shear test on unreinforced clay

Elongation gauge	Force gauge	Gauge factor =0.15	Change in length (mm)	Stress (kg f/m^2)	Elongation gauge	Force gauge	Gauge factor =0.15	Change in length (mm)	Stress (kg f/m^2)
0.04	5	0.75	0.04	600	0.2	106	15.9	1.68	12921
0.08	7.5	1.1	0.08	880	0.04	108	16.2	1.72	13244
0.12	9.5	1.4	0.12	1121	0.08	110	16.5	1.76	13497
0.16	13	1.9	0.16	1523	0.12	112	16.8	1.8	13749
0.2	16	2.4	0.2	1925	0.16	115	17.25	1.84	14124
0.04	19	2.85	0.24	2286	0.2	117	17.55	1.88	14377
0.08	22	3.3	0.28	2694	0.04	118	17.7	1.92	14508
0.12	25	3.75	0.32	3012	0.08	121	18.15	1.96	14810
0.16	27	4.05	0.36	3254	0.12	123	18.45	2	15138
0.2	31	4.65	0.4	3738	0.16	125	18.75	2.04	15392
0.04	32	4.8	0.44	3861	0.2	127	19.05	2.06	15642
0.08	36	5.4	0.48	4346	0.04	129	19.2	2.12	15778
0.12	38	5.7	0.52	4589	0.08	130	19.5	2.16	16032
0.16	41	6.15	0.56	4954	0.12	132	19.8	2.2	16288
0.2	43	6.45	0.6	5198	0.16	134	20.1	2.24	16543
0.04	46	6.9	0.64	5564	0.2	136	20.4	2.28	16798
0.08	49	7.35	0.72	5933	0.04	137	20.55	2.32	16931
0.12	51	7.65	0.76	6178	0.08	139	20.85	2.36	17187
0.16	54	8.18	0.8	6545	0.12	141	21.15	2.4	17443
0.2	57	8.55	0.84	6912	0.16	142	21.3	2.44	17567
0.04	60	9	0.92	7238	0.2	144	21.6	2.48	17832
0.08	63	9.45	0.96	7651	0.04	147	22.05	2.52	18213
0.12	65	9.75	1	7898	0.08	149	22.35	2.56	18471
0.16	68	10.2	1.04	8267	0.12	150	22.5	2.6	18604
0.2	71	10.65	1.08	8363	0.16	152	22.8	2.64	18862
0.04	74	11.1	1.12	9006	0.2	153	22.95	2.68	18966
0.08	76	11.4	1.16	9254	0.04	155	23.25	2.72	19254
0.12	78	11.7	1.2	9502	0.08	156	23.4	2.76	19389
0.16	81	12.15	1.24	9873	0.12	157	23.55	2.8	19523
0.2	84	12.6	1.28	10243	0.16	159	23.85	2.84	19782
0.04	86	12.96	1.32	10493	0.2	160	24	2.88	19917
0.08	88	13.2	1.36	10742	0.04	161	24.15	2.92	20051
0.12	90	13.5	1.4	10992	0.08	162	24.3	2.96	20186
0.16	94	14.1	1.44	11486	0.12	163	24.45	3	20322
0.2	95	14.25	1.48	11614	0.16	164	24.6	3.04	20457
04	97	14.55	1.52	11865	0.2	165	24.75	3.08	20592
0.08	100	15	1.56	12238	0.04	167	25.05	3.12	20853
0.12	102	15.3	1.6	12486	0.08	168	25.2	3.16	20989
0.16	104	15.6	1.64	12742	0.12	169	25.35	3.2	21125
0.16	170	25.5	3.24	21261	0.04	187	28.05	3.92	23596
0.2	171	25.65	3.28	21397	0.08	187	28.05	3.96	23608
0.04	172	25.8	3.32	21533	0.12	187	28.2	4	23747
0.08	173	25.95	3.36	21670	0.16	188	28.2	4.04	23759
0.12	174	26.1	3.4	21806	0.2	188.1	28.21	4.08	23780
0.16	175	26.25	3.44	21943	0.04	188.1	28.21	4.12	23793
0.2	176	26.4	3.48	22080	0.08	188.2	28.23	4.16	23822
0.04	177	26.55	3.52	22217	0.12	188.5	28.27	4.2	23869
0.08	178	26.7	3.56	22354	0.16	188.6	28.29	4.24	23898
0.12	179	26.85	3.6	22492	0.2	188.7	28.3	4.32	23932*
0.16	179.2	26.88	3.64	22562					
0.2	179.5	26.92	3.68	22574					
0.04	181	27.15	3.72	22779					
0.08	183	27.45	3.76	23043					
0.12	185	27.75	3.8	23307					
0.16	186	27.9	3.84	23445					
0.2	186	27.9	3.88	23457					

*maximum of uniaxial stress in unreinforced clay

A_0=12.5 (cm^2) = primitive area of soil sample in shear box
L= 8 cm = primitive length
D= 4 cm = primitive diameter
For illustrating only the last columns for other tables are being considered and demonstrated.

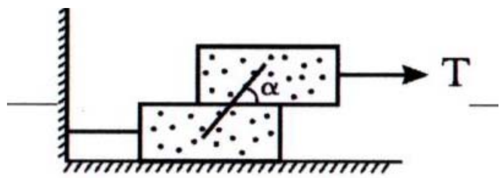
Table 2. Uniaxial shear test on reinforced clay - 0 degree (horizontal) of setting geotextile



Elongation gauge	Force gauge	Gauge factor =0.15	Change in length (mm)	Stress (kg f/m^2)
0.04	197	29.55	5.15	25266
0.08	200.7	30.1	5.2	25754
0.12	200.8	30.14	5.24	25771
0.16	201	30.15	5.24	25810
0.2	201.4	30.2	5.24	25846*

*maximum of uniaxial stress for horizontal geotextile - set

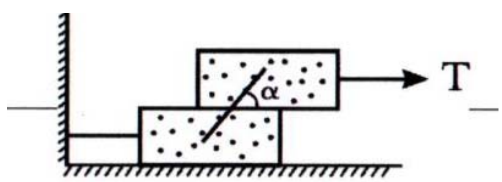
Table 3. Uniaxial shear test on reinforced clay - 30 degree of setting geotextile



Elongation gauge	Force gauge	Gauge factor =0.15	Change in length (mm)	Stress (kg f/m^2)
0.04	205	30.45	4.70	25880
0.08	207	30.75	4.71	26139
0.12	208	31.20	4.74	26404
0.16	209	31.35	4.77	26539
0.2	210	31.50	4.78	26808*

**maximum of uniaxial stress for 30 degree geotextile - set

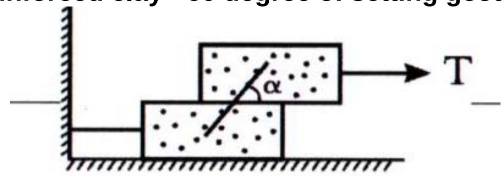
Table 4. Uniaxial shear test on reinforced clay - 45 degree of setting geotextile



Elongation gauge	Force gauge	Gauge factor =0.15	Change in length (mm)	Stress (kg f/m^2)
0.04	209	31.35	5.26	26845
0.08	211	31.5	5.3	26988
0.12	211.5	31.65	5.35	27134
0.16	211.5	31.72	5.4	27212
0.2	212	31.8	5.4	27212*

*maximum of uniaxial stress for 45 degree geotextile – set

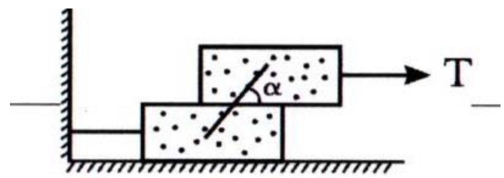
Table 5. Uniaxial shear test on reinforced clay - 60 degree of setting geotextile



Elongation gauge	Force gauge	Gauge factor =0.15	Change in length (mm)	Stress (kg f/m^2)
0.04	225	33.75	6.04	29205
0.08	228	34.2	6.12	29626
0.12	231	34.59	6.18	29980
0.16	231	34.59	6.18	29980
0.2	231	34.59	6.18	29980*

*maximum of uniaxial stress for 60 degree geotextile - set

Table 6. Uniaxial shear test on reinforced clay - 90 degree of setting geotextile



Elongation gauge	Force gauge	Gauge factor =0.15	Change in length (mm)	Stress (kg f/m^2)
0.04	202	30.30	4.75	25515
0.08	203	30.45	4.78	25720
0.12	203.5	30.47	4.80	25914
0.16	204	30.6	4.85	25932
0.2	204	30.6	4.90	26085*

*maximum of uniaxial stress for 90 degree geotextile - set

Table 7. Variation of shear strength in clay strengthened by geotextile

Alignment of setting geotextile to failure plane (degree)	C = shear strength (kg f/m^2)
horizontal	12923
30	13404
45	13641
60	14990
90	13042
unreinforced	11966

It was observed during experiments that due to increasing shear strength of clay reinforced by geotextile, the stability of soil in slopes increases. By utilizing geotextile the adhesive increased about 25%, which cause more stability in conduits (Table 7). The variant in angle with in shear strength of the soil has been presented in Table 7).

It should be noted that the uniaxial shear strength derived from the following equation.

$$C = qu / 2$$

Where qu is uniaxial strength and C is cohesive of clay

Maximum increase in shear strength in clay soil = (14990- 11966)/ 11966 = 25%

In Fig.1, conveyance structure that reinforced by geotextile (setting 60 degrees to failure plane) in north of Iran-Lahijan, is demonstrated.It was found that when geotextile sheets set in 60 degrees to failure plane a maximum increase in shear strength (about 25%)

would be obtained. However, if the geotextile sheets set in range between 0-90 degrees to failure plane, it could improve shear strength of clay too. Thus utilizing geotextile sheets in clay soils can retrofit the shear strength and the best angle for setting geotextile sheets is 60 degrees to failure plane approximately.

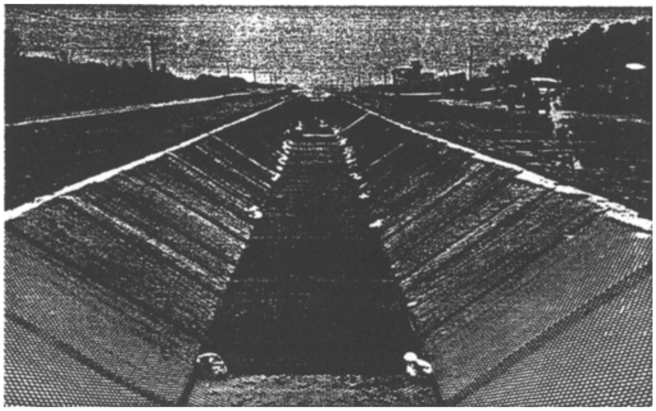


Fig.1. Strengthening and lining conduits by polymer materials

CONCLUSIONS

- In order to increase shear strength of clay, one method is reinforcement by geotextiles.
- Geotextiles increased shear strength of clay with an increase in angle of failure plane up to 60 degrees.
- The best angle of reinforcing the clay by geotextiles was about $\alpha = 60^{\circ}$ to horizontal failure plane.
- Maximum increasing the shear strength of clay soils was about 25%.
- Generally, the more simple technology with reduction in movements of soil particles is the advantage of reinforced soil. This advantage is due to increase in shear strength of soil provided by polymer materials.

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REFRENCES

Hibbeller, R.C. 2008. Mechanism of Material, (3rd ed.). Prentice Hall, New Jersey.

Koerner, R. 2007. The GSI Newsletter/Report. Geosynthetic Institute, Drexel University.

Ling, H.I. and K. Matsushima. 2002. Shear strength parameters of soil- geosynthetic interface under low confining pressure using a tilting table. Geosynthetics Internationa 9(4):373-380.

Lopez, P.C. and M.L. Lopez. 2001. Shear behavior of geosynthetics in the Inclined-Plane test. Geosynthetic International 8(4):327-342.

Mardookhpour, A.R. 2003. New design in minimum use of earth materials that will increase the safety factor of upper and lower slopes condition in earth dams. Ph.D. thesis, Islamic Azad university of Science and Research branch of Tehran, Iran. pp.19-99.

Mardookhpour, A.R. 2004. Application of geotextile in coastal area. Power and Water Institute of Technology, Ministry of Power of Iran. p.18.

Noorzad, R. 2000. Behavior characteristics of geotextile reinforced sand. Ph.D. thesis, Sharif University, Iran. pp.44-57.

Saxena, K. 2004. Geosynthetics in embankment. First seminar on application of geosynthetic in hydraulic structures. IRCOLD. pp.24-36.

Scuero, M. 2004. Geomembrane in rehabilitation of canals. First Seminar on application of geosynthetic in hydraulic structure. IRCOLD. pp.44-63.

Xenaki, V. 2001. Experimental investigation of the interaction mechanism of the geofoam–sand interface by direct shear test. Ph-D thesis, University of Patras, Greece. pp.46-99.

Zhen, C. and H. Yin. 2001.Elastic analysis of soil geosynthetic interaction. Ph.D. thesis, Hong Kong Polytechnic University, Hong Kong. pp.76-93.