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Effect of Consolidation Duration in Pullout Characteristics of GHD in Saturated Clay

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INTRODUCTION

This paper describes the experimental results of pullout tests on Geosynthetic Horizontal Drain (GHD) in reconstituted saturated clay. Effects of various consolidation durations in pullout characteristics have been investigated at normal stress (σ_n)of 30, 50 and 70 kPa as shown in **Table 1** and **Fig. 1**.

MATERIALS AND TESTING METHOD

Soft clay recovered from Tokyo Bay is completely reconstituted by seiving through 75 micron seives, making slurry from the fines with consistency of twice the liquid limit and one dimensionally consolidating at normal pressure of 50 kPa. LL, PI, Sp. Gr., and w_n of the sample thus obtained are 74%, 44, 2.65 and 60% respectively.

GHD having hard poly vinyl chloride core and non-woven geotextile filter with total nominal thickness 10 mm, width 150 mm and embedment length 245 mm is tested.

Laboratory tests have been conducted using pullout apparatus with inner dimensions of 245 mm long, 160 mm wide and 100 mm high. GHD is kept in between two rectangular blocks of clay sample. Pullout tests are carried out immediately after applying normal load (no consolidation before pullout), after 50% of consolidation, after 24 hours and after 168 hours of consolidation at prescribed normal pressure as shown in **Table 1** and **Fig. 1.** Pullout is done at the rate of 1 mm/minute. Elongations at four different locations along the embedded length of GHD (D1, D2, D3, D4), clamped end elongation (D0), vertical displacement, normal load and pullout forces are measured during pullout. Details on GHD sample preparation and apparatus can be found in Pradhan et. al (1996a, 1996b).

TEST RESULTS AND DISCUSSIONS

Fig. 2 compares the variation in pullout force for 1 day and 7 days consolidation. Slightly stiffer response can be observed for the 7 days compared to that for 1 day consolidation. However there is no change in change in failure mode (tension failure in both cases) and the corresponding curves follow very closely in both cases. Thus it is clear that practically almost all the shear strength is developed immediately after the end of primary consolidation. Strength and stiffness gained after the end of primary consolidation is practically not significant.

Table 1 Summary of test program & results

GHD width mm	σ_n kPa	con. dur. hour	P_{max} kN/m	η %	t at P_{peak} min	Failure Mode
152	30	0	8.15	92	7	pullout
152	30	24	9.02	100	20	pullout
152	50	0	10.75	75	11	pullout
152	50	0.85	12.04	82	12	pullout
150	50	24	14.45	97	37	tension
152	70	0	14.10	79	-	pullout
152	70	24	18.45	89	31	tension
152	70	168	18.57	90	31	tension

P_{max} : maximum pullout force; η: Efficiency = Φ_{IF} / Φ_{clay} , Φ_{IF} = $\tan^{-1}[\tau_{max}/\sigma_n]$, Φ_{clay}=32°, t at P_{peak} : time taken to reach P_{peak}

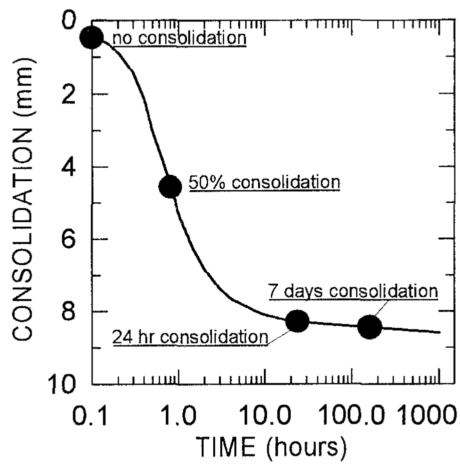

Fig. 1 Consolidation Points Before Pullout

Effect of confinement on GHD stiffness can also be observed from **Fig. 2**. Displacement measured at point D0 is just outside the embedment length while points D1-D4 are within embeded portion of GHD. Significant increase in stiffness and a reduction in failure strain can be seen due to soil confinement.

Figs 3-4 compare the pullout force-displacement relationships for the cases of no consolidation before pullout, for 50% consolidation, 1 day, and 7 days consolidation. Significant reduction in pullout resistance is obvious for the cases of pullout without prior consolidation. Pullout shear strength at σ_n of 50 kPa increased by about 12% when it was 50% consolidated prior to pullout. For unconsolidated and partly consolidated specimen, interface shearing efficiency is lower as shown in **Table 1**. Lower efficiency indicates that failure of GHD reinforced embankment will occur along clay-GHD interface In such cases, failure mode is invariably due to pullout of GHD regardless of normal pressure unless the GHD length is sufficiently long. This type of failure was reported by Kamon et. al. (1995) in GHD reinforced full scale test embankment.

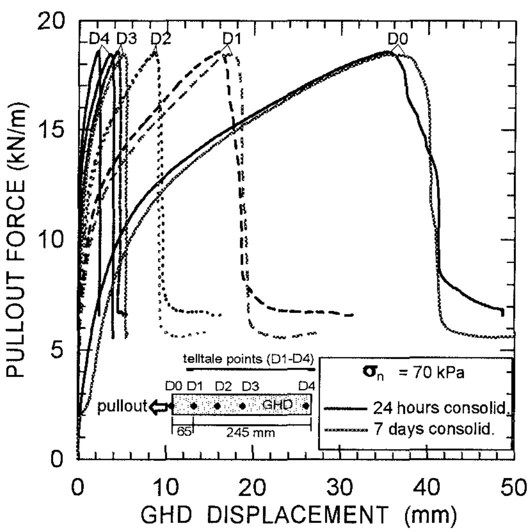

Fig. 2 Comparison of Pullout behaviours after 1 day and 7 days of consolidation

Comparison of **Figs. 3 & 4** reveals that mainly rigid body movement of GHD occurs in case of *pullout failure*. Thus in analysing GHD reinforced embankment, GHD extension can be neglected in such type of failure without significant effect in result. However, for *tension failure* mode, GHD extension is significant as also shown by Pradhan et. al (1996a, 1996b) and it must be taken into account in analysis.

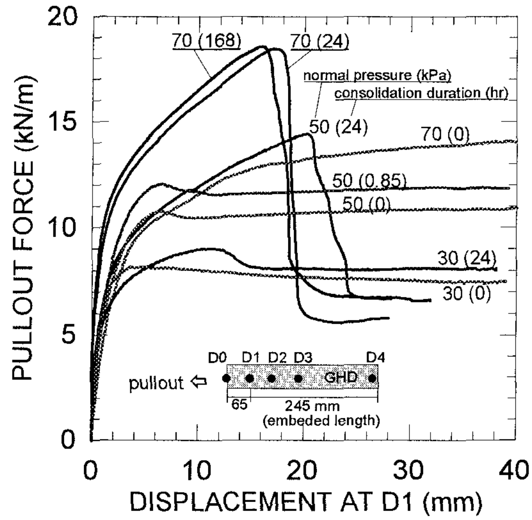

Fig. 3 Pullout Force-Displacement Relationship Near Front End (D1)

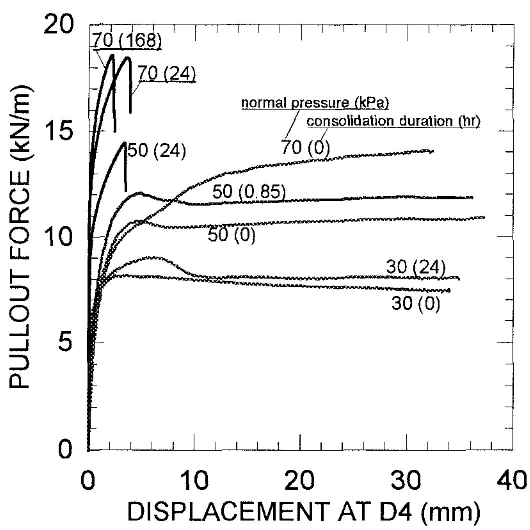

Fig. 4 Pullout Force-Displacement Relationship Near Rear End (D4)

REFERENCES

Pradhan, T. B. S., Shiwakoti, D. R.., Okamoto, M., Ikedo, S. (1996a). Pullout behaviour of geosynthetic horizontal drains in saturated clay, *12th South East Asian Geotechnical Conference*, Malaysia.

Pradhan, T. B. S., Shiwakoti, D. R..& Goro Imai (1996b). Effect of normal pressure and width of geosynthetic horizontal drain in pullout behaviour using saturated clay, *International symposium on earth reinforcement (IS Kyushu 96)*, Japan.

Kamon, M., Akai, T., Fukuda, M., Nanbu, Y., Fukuhara, Toki, T., M.& Kuroki, T.(1995). Failure test of high water content soft clay embankments reinforced by geosynthetic horizontal drain materials-part 1, 30th JSSMFE conference (in Japanese)