The cementation effects in aged compacted soils

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1. Introduction

Compacted soils from remains obviously underwent a long time, at least 1000 years, so cementation effects, mainly aging effects, should occur in these soils. Based on analyses of tests results about remains soils carried out by Onitsuka(2003), strength parameters, consolidation yield stress p_c, cohesion c and frictional angle ϕ, changes in remains soils are regarded as results of cementation effects. To evaluate the influence of cementation effects on remains soils strength parameters, tests results on samples from another remains, Mojiaoshan(in Chinese), are shown with previous results achieved by Onitsuka(2003).

2. Background and laboratory tests

The samples were obtained from Mojiaoshan (constructed at about B.C. 3000) by cylindrical samplers 10cm in diameter and 25cm in height, then samples were trimmed into specimens, 6.18cm in diameter and 2cm in thickness. Direct shear tests, at speed of 0.8mm/min, and oedometer tests were carried out on both undisturbed and remolded specimens. Figure 1 presents the results of SPT test, and Table 1 shows physical properties of samples from Mojiaoshan. Photo 1 shows one cross section in Mojiaoshan, where layer-state, thickness range from 5cm to 10cm, rammed earth fill can be recognized to prove that Mojiaoshan remains was constructed by technique of compaction.

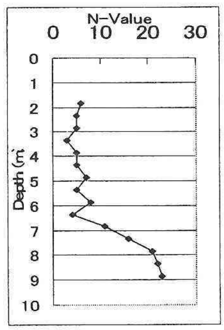

Figure 1. N-Value for Mojiaoshan

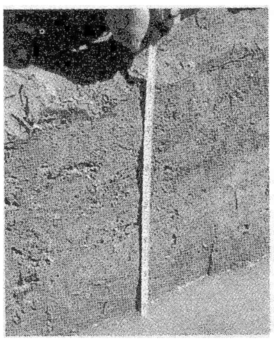

Photo1. Layer-state earth fill of Mojiaoshan

Table 1. Physical properties of soils sampled from Mojiaoshan

Sample	Depth (m)	Class.	ρ_s	w_n (%)	ρ_t (g/cm^3)	w_p (%)	w_L (%)	Particle size distribution(%)			
								Gravel	Sand	Silt	Clay
M1	0.15~0.40	CL	2.65	28.5	1.911	21.1	34.5	0.0	30.5	22.5	47.0
M2	0.65~0.90	CL	2.64	34.8	1.865	16.3	35.1	0.2	2.4	44.9	52.5
M3	1.15~1.40	CL	2.68	24.0	1.903	15.5	28.4	0.3	34.0	28.2	37.5
M4	1.65~1.90	CL	2.63	27.2	1.938	19.2	30.0	0.2	2.8	57.0	40.0
M5	2.15~2.40	CL	2.62	32.0	1.881	16.5	30.9	0.2	1.7	56.6	41.5
M10	5.65~5.90	SF	2.70	27.7	1.983	15.6	29.3	0.2	71.0	6.3	22.5
M11	6.15~6.40	CL	2.68	24.3	1.997	18.2	32.6	0.0	21.5	24.7	53.8
M12	6.65~6.90	CL	2.71	21.3	2.053	13.8	33.0	0.0	13.4	33.7	52.9
M15	8.15~8.40	CL	2.67	22.2	2.060	16.9	39.6	0.3	17.3	78.4	4.0

3. Results and Discussion

Oedometer tests results of samples obtained from different depth are shown in the Figure 2, where approximately theoretical consolidation yield stresses (total stress) for young sedimentary soils are also plotted as the dashed line, and Figure 3 and Figure 4 shows shear strength parameters, cohesion c and frictional angle ϕ, varieties with depth respectively. Symbol UU means undisturbed-unsoaked specimens, and RU abbreviates for remolded-unsoaked specimens. Water contents and dry densities in remolded specimens are adjusted to the same as those of undisturbed specimens.

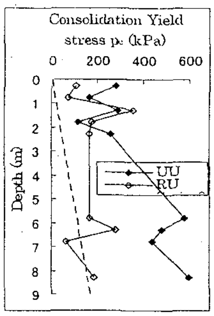

Fig.2 p_c vs. depth

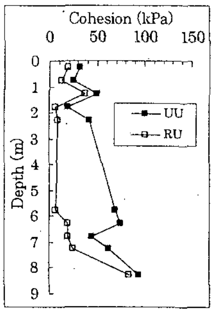

Fig.3 Cohesion vs. depth

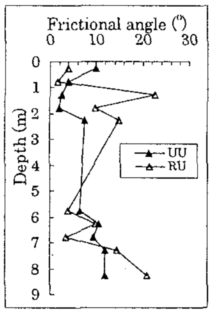

Fig.4 Frictional angle vs. depth

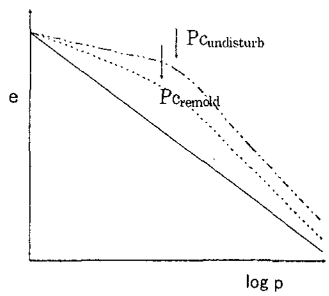

Fig.5. Ideal e-logp curve for remolded and undisturbed aged compacted soils

Considering different tests results on undisturbed and remolded specimens, here cementation degree ratio CDR=$\frac{p_{c_{undisturb}}}{p_{c_{remold}}}$, visualized in Figure 5, is employed to describe the cementation effects, not the process of cementation. Figure 6 shows CDR results of Mojiaoshan, and previous results are also plotted. In Figure 7, 8, cohesion varieties, $\frac{c_{undisturb}}{c_{remold}}$, and frictional angle varieties, $\frac{\tan\phi_{undisturb}}{\tan\phi_{remold}}$, due to cementation effects are plotted with corresponding values of CDR. In these figures, M means Mojianshan, Y means Yoshinogari Fun-kyu tomb and T means Tu-dun tomb.

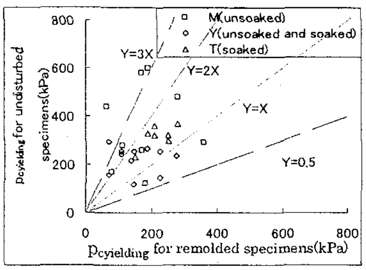

Fig.6. CDR for some historical remains

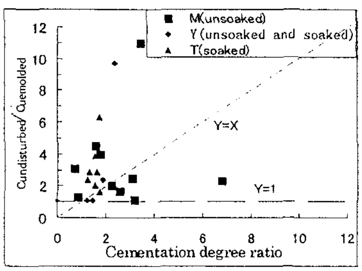

Fig.7. Cohesion varieties versus CDR

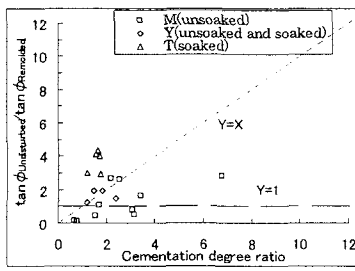

Fig.8. Frictional angle varieties vs. CDR

4. Conclusion

Based on analysis of results of investigation not only on Mojiaoshan, but also on the previous investigated historical remains, following conclusion can be drawn:

1. Aging effect affects compacted soils behaviors, and it can be treated as one kind of cementation effects, considering of other influences factors also having effects on soil behaviors. 2. Oedometer and direct shear tests results show that cohesion and consolidation yield stress are good indexes reflecting the cementation effects in such kind of soils.3. Graphs on CDR versus soil shear strength parameters, c and $\tan\phi$, changes are plotted, but plots in graphs seem to be very discrete, so how to explain the discretion in these graphs is the next subject.

References

(1) ONITSUKA, K. and SATO, M. (2003): "Geotechnical properties of fill remains such as Yoshinogari north burial mound and construction technique," Journal of JSCE, III-63, 217-230 (in Japanese). (2) ONITSUKA, K. et al.(2003): "Geotechnical characteristics and construction methods of Yoshinogari Fun-kyu tomb in Japan and Tu-dun tombs in China," Journal of JSCE, III-63, No.736. (3) T. William Lambe and Robert Whiteman: "Soil Mechanics,".