Research on Influence of Time on the Shear Behavior of Compacted Silty Soil

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Introduction

Generally, the time-effect on the strength of soil is studied by unconfined compression test or triaxial test. Yet, in this paper, the time effect on strength of silty soil was studied by direct-shear test, and based on the results of the tests we will report on the initial phase of a laboratory research to document the time-effect on direct-shear behavior of compacted silty soil.

Materials and Methods

Soil samples were taken from Yoshinogari, Saga Prefecture in Japan, and the index properties of this soil are given in Table 1. Specimens for direct-shear test were compacted at four different molding water contents using three different compaction energies, corresponding to compactive efforts consistent with Standard Effort-550kN-m/m^3 (25 blows/layer), Reduced Effort-330kN-m/m^3 (15 blows/layer), Modified Effort 1100kN-m/m^3 (50 blows/layer). Specimen were prepared at moisture contents of 30.0%, 35.0%, 40.0%, 42.5% to permit evaluation of specimens compacted well below and above the optimum moisture contents for all three compactive efforts. The optimum moisture content and maximum dry density for the specimens compacted using Standard Effort were 37.0% and 1.27g/cm^3, respectively. The optimum moisture content and maximum dry density for the other energies are given in Table 2. As shown in Figure 1, the maximum dry density increased with increasing compactive effort and the optimum water content decreased as typical of most soils. After samples were cured for 0, 6, 12 months, direct-shear tests were carried on respectively.

Table 1-Index properties for soil

Property		Value
Specific Gravity		2.62
Atterberg	W_L(%)	61.6
	W_P(%)	37.1
Limits	I_P	24.5
Grain	Gravel	1.0
Size	Sand	31.0
Distribution	Silt	35.5
%	Clay	32.5
Classification		MH

Table 2- Optimum moisture content and maximum dry densities compacted using a range of energies

Effort		Opt. W%	ρ_{dmax}
	KN-m/m3	%	g/cm^3
Reduced	330	40.0	1.21
Standard	550	37.0	1.27
Modified	1100	35.0	1.30

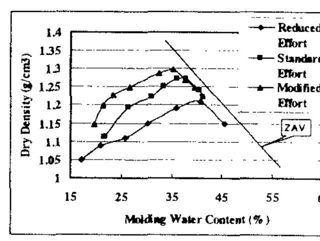

Figure 1- Dry density versus molding water content for compacted soil

Results and Discussion

In Figure2-(a), (b), (c) the cohesion obtained from direct-shear test are plotted as a function of molding water content for curing time 0, 6, 12 months respectively. These figures show the cohesion of the compacted silty samples is higher with increased compactive effort. The greatest cohesion (174kPa, 177kPa, 178kPa, cured for 0, 6, 12 months respectively) was obtained for specimens compacted at the Modified Effort (1100kN-m/m^3) and the lowest molding water content (30%). The cohesion was up to about 2 times higher than specimens compacted at the same water content but using Reduced Effort. All specimens, regardless of compactive effort, exhibited similar cohesions when compacted wet of optimum, as illustrated in Figure 2. The dry densities of all the specimens compacted wet of optimum, greater than 40%, are similar and it stands to follow that their cohesions should be similar as well.

Figure 3 shows the relation between curing time and cohesion. In Figure 3-(c) and (d), which corresponds to Figure 3-(a) and (b) respectively, a ratio of cohesion at lasting time 6 and 12 months to cohesion at 0 month was calculated for each specimen compacted at the same molding water content. From these figures, it can be seen that when specimens were compacted dry of optimum water content, the cohesions merely increase a little within one year, not more than 7%. Nevertheless, when specimens were compacted wet side of optimum

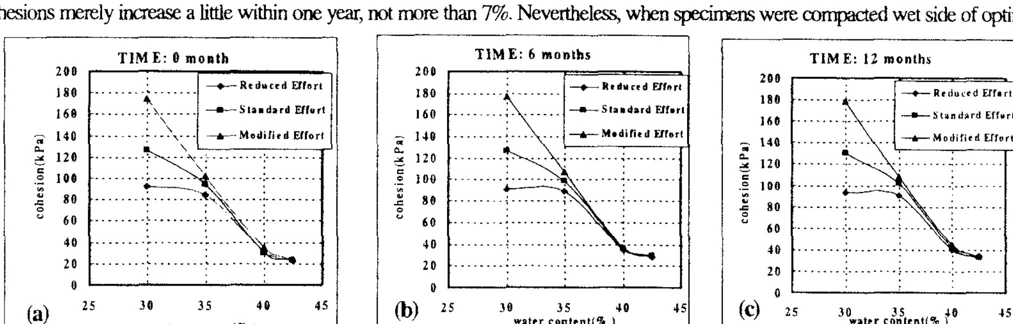

Figure 2-Cohesion for compacted specimens cured for 0, 6, 12 months

water content, the cohesions increased up to 30% to 50%. Besides, it is also illustrated that regardless compacted wet or dry side of optimum water content, the higher the water content is, the greater the increased portion of cohesion is. This kind of strength gaining can be termed as thixotropic aging effect, due to occurring at low effective stresses and under undrained conditions.

The results of angle of internal friction of direct-shear are shown in Figure 4, in which (c) and (d) corresponds to (a) and (b) respectively, a ratio of internal friction angle at lasting time 6 and 12 months to friction angle at 0 month was calculated for each specimen compacted at the same molding water content. From Figure 4-(a) and(b), it is illustrated that the internal friction angles of specimens falled down with increase of the water content, about 38° with water content 30%, and about 20° with water content 42.5%. This outcome may be explained by the arrangement of particles in a compacted soil, as originally conceived by Lambe, which is illustrated in Figure 5. When compacted dry of the optimum, the soil particles have a tendency of low degree of orientation, termed as "flocculated arrangement of particles". This arrangement of particles tends to increase the friction among the soil particles. Yet, if the water content is increased, degree of orientation of particles tends to increase. A system of parallel particles, which is approached at point C (in Figure 5), has been termed a dispersed system, which tends to decrease the friction among compacted particles. From Figure 4-(c) and (d) we can see that the friction angle of specimens compacted dry of optimum increased with lasting time a little, less than 7.5%, while the angles of specimens compacted wet of optimum tend to decreased with time. In case of specimen with 42.5% water content and compacted by Modified Effort, the greatest reduction portion was achieved, about 12%. This test result may be explained as that the structure of flocculated arrangement of particles at the dry side of the optimum and the structure of parallel arrangement of particles at the wet side of the optimum (Figure 5) may be strengthened with passage of time.

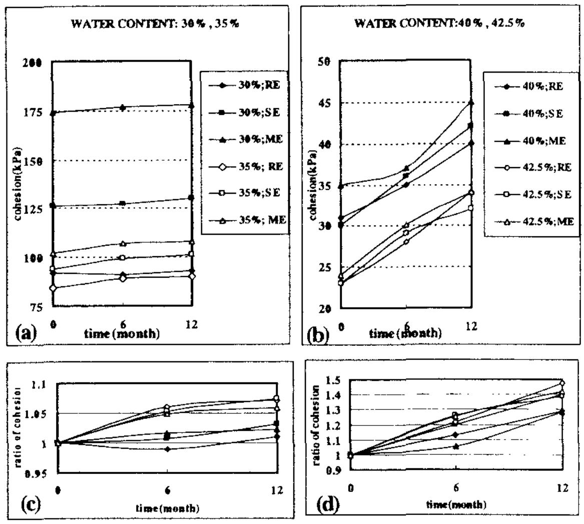

Figure 3-Cohesion vs Curing time for different water content
RE:Reduced Effort; SE:Standard Effort; ME:Modified Effort

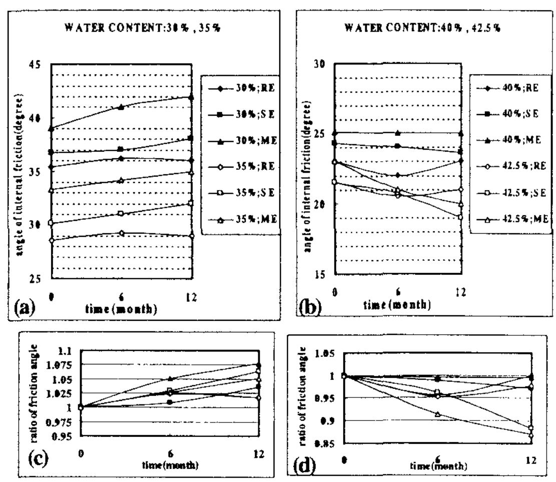

Figure 4-Angle of internal friction vs Curing time for different water content

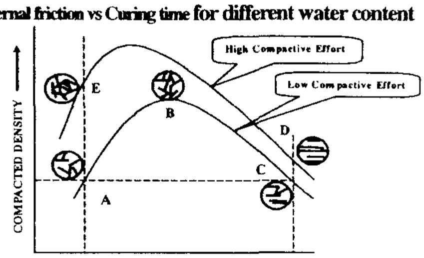

Figure 5-Effect of Compaction on Soil Structure

(from T.W. Lambe)

Conclusion

1.For this particular silty soil, the cohesion got from direct-shear test will increase with passage of time; and the addition of cohesion depends on remolding water content and compactive effort.

2.The angle of internal friction from direct-shear test of this soil tends to increase with time when compacted dry of optimum; however tends to decrease with time while compacted wet of optimum.

3.The next phase of this project is to take further steps to investigate the structure of compacted specimen of this soil.

References

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