Unconfined Compression Strength of Lime-stabilized Soil used for Backfill Material of Buried Flexible Model Pipe with Wet-Dry Condition Simulation

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ABSTRACT

An idea of using lime-stabilized soil as the backfill material in a model test of flexible buried pipe is going to be implemented. Determination of lime-stabilized soil strength needs to be done for a preliminary stage of the model test. In order to simulate the field condition with wet-dry cycle state, lime-stabilized soil mixed in the field was transported to the laboratory, divided into three water content condition (i.e. 15%, 23% and 28%), compacted to achieve 90% relative dry density condition, cured for up to 8 days, and then being subjected to unconfined compression tests. In this particular relatively short time period observation, the water content seems to be a major concern in the determination of the unconfined compression strength, while the strength seems to be constant day by day during the curing period.

1. INTRODUCTION

Lime, either in form of quicklime or hydrated lime, is commonly used in stabilization of clay soil used in many types of construction. Lime application into suitably reactive soil causes modification of the properties of the soil in early stage after the mixing (i.e. reduction of plasticity, drying-out of excessively wet material, and improvement of material workability), and in further stage with remaining availability of lime, generally within 1-3 days, calcium silicate hydrate and calcium aluminate hydrate gels are produced, which contribute to the stabilization of soil and the further improvement of the material strength (Holt and Freer-Hewish, 1998).

By considering that the strength of lime-stabilized soil could be enhanced double or even more as compared to its original material, and since the density of the backfill material which implies its stiffness and strength plays an important role in the interaction between backfill soil and flexible buried pipe (Kuwano and Miyashita, 2008), lime-stabilized soil could be applied as backfill material as well. A model test of flexible buried pipe using lime-stabilized soil as the backfill material is going to be implemented. Strength of lime-stabilized soil which intends to increase day by day needs to be determined as a preliminary step of the model test. Due to pozzolanic reaction of lime-stabilized soil and in order to simulate the condition in the field where the water content of backfill material might be changed due to the environmental condition, lime-stabilized soil was treated with care of different water content and different curing treatment.

2. MATERIAL AND TEST CONDITION

The materials used in this test were lime-stabilized soil with 2%, by weight of lime and its original material transported from one of recycled soil plant in Tokyo Metropolitan Sewerage Service Corporation which is located in Nakagawa. The original material was surplus soil came from construction site in Japan. Both materials properties are summarized in the table 1 and figure 1.

Samples of both materials were made by compacting 10 layers of soil inside a plastic mold until 90% of relative dry density was achieved. These samples were then cured with specifically curing treatment for a relatively short time period, up to 7 days prior to being subjected to unconfined compression test. The testing condition of the materials and the curing treatments applied to it are summarized in the table 2.

Table 1. Properties Comparison between Original Material and Lime-stabilized Material

Properties	Original	Lime-stabilized
Initial Water Content	23%	26%
Maximum Dry density	1.563	1.685
Optimum Water Content	23%	19%
Specific Gravity	2.71	2.75

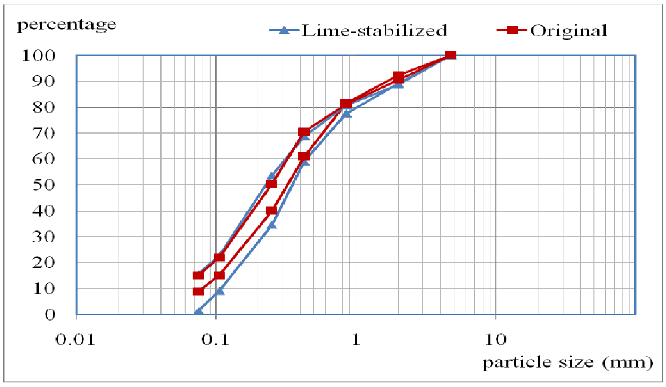

Figure 1. Particle Size Distribution Curve

Table 2. Testing Condition of the Materials and Curing Treatment Applied

Name	Initial WC	Curing Treatment
Ap	28%	keeping the sample inside the plastic bag and plastic box
Aw		soaking the sample in the water
Bp1	23%	keeping the sample inside the plastic bag and plastic box
Bp2		
Bw		soaking the sample in the water
Bd		leaving the sample on the table
Cp	15%	keeping the sample inside the plastic bag and plastic box
Cw		soaking the sample in the water
Ow	26%	soaking the sample in the water
Od		leaving the sample on the table

Keywords: unconfined compression test, lime-stabilized soil, water content, curing period, day by day strength
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3. TEST RESULT AND DISCUSSION

Unconfined compression test was conducted day by day during the curing period up to 7 or 8 days with 1% per minute strain rate and the result is summarized in the figure 2. The average strength of the original soil with 25% initial water content as the site condition was around 85 kPa, while the average strength of lime-stabilized soil with 23% initial water content as received from the site was about 300 kPa. It means that the lime could improve the strength of the lime-stabilized soil to be about three times of the original material strength.

Day by day unconfined compression strength of the lime-stabilized soil, either was treated by curing inside the plastic bag or was immersed in the water, intends to be constant until the 7th days of curing period. It implies that there is no such significant improvement of the lime-stabilized soil with addition of 2% lime. It seems the affinity of this particular soil for lime is not satisfied yet by the amount of 2% lime. Since the lime fixation point could not be passed, it means there is no more lime available for other chemical reactions which are causing further increment of soil strength, as observed as constant strength tendency of lime-stabilized soil in this research.

On the other hand, the strength of drying specimens (i.e. Bd and Od) increased day by day during the curing period, which is probably due to the effect of less saturated soil condition. The strength increment of Od specimens indicates that the cause of Bd specimen's strength increment might not be the chemical reactions between soil and lime.

The specimens cured inside the plastic bag were relatively stronger than the specimens immersed in the water. The contact between soil particle of immersed specimens seem to be loosened by the water. Bp specimen which was in optimum water content condition showed highest strength as compared to Ap, Cp and all the soaked specimens.

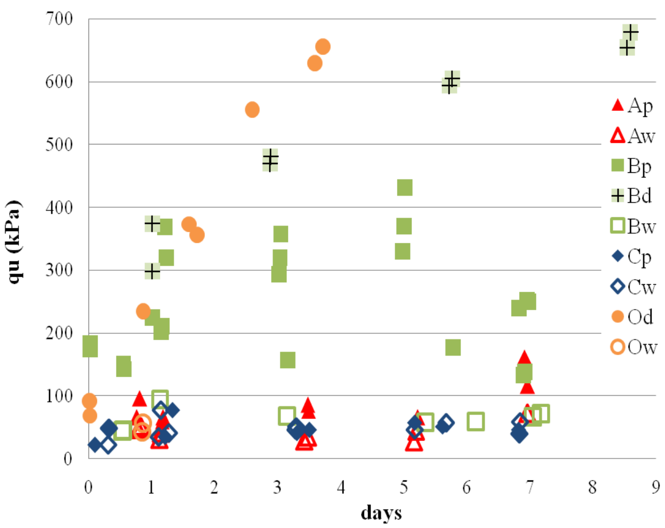

Figure 2. Unconfined Compression Strength of Lime-stabilized Soil at Different Curing Period

Based on those tests result, it seems that water content is a major factor that govern the strength of the lime-stabilized soil specimen with 2% by weight of lime content. It shows a trend of that relationship as appeared in figure 3. The strength of the specimen increased with the decrease of water content, and when the specimen is in saturated condition, the strength seems to be in the same range as the strength of the original material. The water content condition of soil material when the specimen is being compacted seems to have some effect on the unconfined compression strength of the specimen as shown by the strength of Cp specimen which is shifted lower from the trend.

Furthermore, the trend of relationship between water content and unconfined compression strength of lime-stabilized soil is quite similar to the trend of the original material. It seems the addition of 2% lime makes the saturated original soil dries faster and reaches the higher strength faster, while still in the path of the same trend. Other possible causes are inhomogeneousity of the materials and the possibility that original material contains some amount of lime as well.

As the implication of this result on the flexible buried pipe model test, the water content condition of backfill material needs to be controlled more or less constant, while the test does not have to wait for a specific curing period since the strength of backfill material is expected to be constant. In the field, the backfill soil strength would be sensitive of water condition, and particularly backfill soil in wet condition might be relatively weak to support the load in term of pipe-backfill soil interaction.

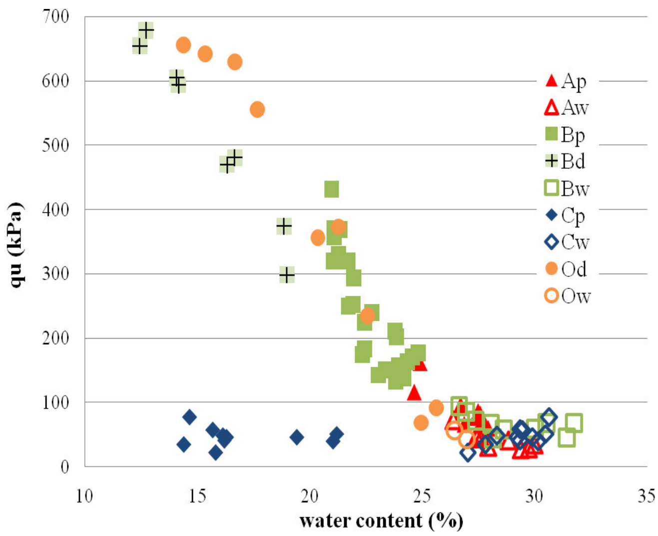

Figure 3. Unconfined Compression Strength of Lime-stabilized Soil at Different Water Content

4. SUMMARY

Unconfined compression test of lime-stabilized soil with the simulation of wet-dry field condition was conducted. With 2% by weight of lime content, the day by day strength of material intends to be constant, while the water content seems to be a major factor governing the strength of the lime-stabilized soil observed in this research.

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