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Influence of clay content on permeability of compacted lateritic soil

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Abstract

This research studied the permeability of compacted lateritic soil in vertical and horizontal directions. The instrument for measuring the coefficient of permeability was performed in cubic mold shape. The soil samples were compacted by static compaction method. The relationship between the coefficient permeability in vertical (K_v) and horizontal (K_h) directions were investigated. The influence of clay content on permeability of compacted laterite soil is studied. The results showed that the K_v and the K_h values sharply decrease when the dry density increases until the maximum dry density. Then they are nearly constant at the relative compaction less than 85% with the water content higher than optimum water content. The K_v/K_h decreases when the water content of the compacted soil increases. The K_v/K_h is in the range of 2-7 when the water content is higher than the optimum water content. The higher clay content is mixed, the lower K value is showed. The increasing in the clay content is especially subject to decrease in the K value by 80 percent.

Keywords: Compacted soil, Laterite, Permeability, Clay content

1. Introduction

Nowadays the natural disaster is more seriously course of the global worming effect such as drought, flooding and variability of the climate. In 2012, the major flooding occurred in Thailand that was serious damage in economics of the whole country. Then it is necessary to apply the resources in the highest efficiency in order to help into the water management. One of the flooding protection systems which is the low construction cost and usually utilize is the earth dam or embankment. The embankment can be applied by various soils as sand, lateritic and weathering soil. In some cases, the clay may be also applied for the core earth dam. In order to achieve the resistance permeability, the soil is compacted. Darcy[1] proposed the equation for calculating the velocity of water through the saturated soil equal the mortification between coefficients of permeability (K) with hydraulic gradient (i). The coefficient of permeability value (K) is one of the important values to design the flooding protection system. The K value is currently applied from the field permeability but the cost of the test quite expensive. Form the studies in the part [2-3]; the vertical permeability which obtained from laboratory is always applied for designation. This value is not the real drainage directional mechanisms. Tian and Teerawut[4] studied the horizontal permeability of soft clay by using the constant rate of strain with drainage in radius direction. That equipment also cannot be applied to the compacted soil. In order to measure the coefficient of horizontal permeability (K_h) of compacted soil, the new cubic mold was built. In order to improve the performance of compacted lateritic soil for the water protection system, the permeability of compacted soil is decreased by increasing the compaction effort energy. The increasing of clay content is also usually applied. Then this study investigated the effect of clay content on the permeability to improve the performance of compacted lateritic soil.

2. Soil sample and testing

Four lateritic soils were applied in this study. Their properties are shown in Table 1. The soil samples were investigated the coefficient of horizontal and vertical permeability. The soil samples were compacted by the static compaction method [5] in the various densities which were equivalent to the compaction by Standard Proctor test.

The soil sample2 were mixed with clay content with percentages of 10, 20, and 30 per weight of dry. The properties of Bangkok clay which was applied for mixing are shown in Table 1. Then the compacted samples were tested to find out the coefficient of vertical and horizontal permeability. The size of aluminum cube mold is 10x10x10 centimeters as shown in Figure 1. The mold was designed for compacting soil and testing the permeability in both vertical and horizontal directions. There are drain parts in vertical and horizontal directions and air vent pipe at the cover for saturation. The testing samples were compacted by the static compaction method. The soil samples were compacted in three layers by hydraulic compression in order to achieve the density equal to the Standard compaction. The back pressure

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Table 1 Properties of soil samples

Properties soil sample	1	2	3	4	clay
Specific gravity (Gs)	2.50	2.54	2.64	2.58	2.30
Liquid limit (LL,%)	22.81	26.43	32.02	31.20	101.20
Plastic limit (PL,%)	20.02	16.34	23.90	22.13	35.20
Plasticity index (PI,%)	2.79	10.09	8.12	9.07	66.00
USCS	ML	ML	SM	SC	CH

(a)

(b)

Figure 1 (a) Cube mold for investigating the permeability of compacted soil (**b)**soil specimen

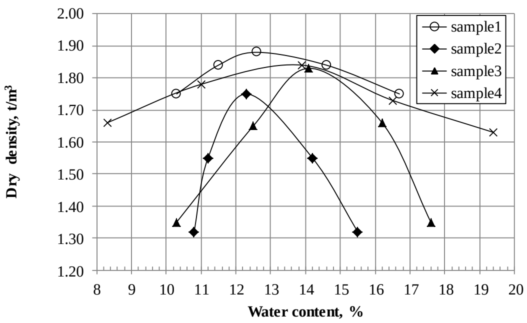

Figure 2 compaction curve of four soil samples

was applied about 100-200 kPa for 24 hour to saturate the sample. And then the pore pressure was applied to investigate the permeability of compacted samples by variable head permeability test.

3. Results and discussion

Figure 2 shows the compaction cure of four soil samples. The maximum dry density and optimum water content of four soil sample are also showed in Figure 2. Figure 3 shows the permeability of compacted four soil samples. All samples showed that the K_v and the K_h values sharply decrease when the water content increases until the optimum water content (dry side of optimum compaction). Then they slightly decrease when the dry density decreases and the water content of compacted soil increases (wet side of optimum compaction).

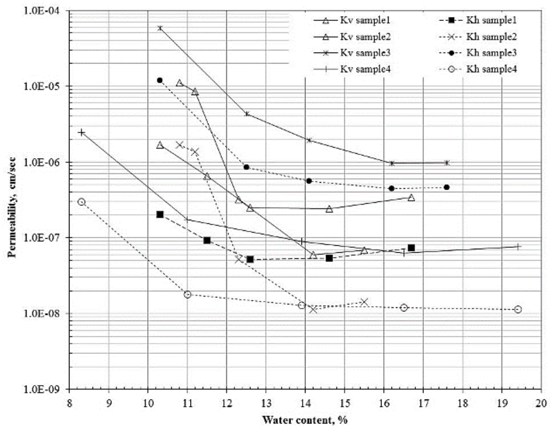

Figure 3 Permeability of four compacted soil samples

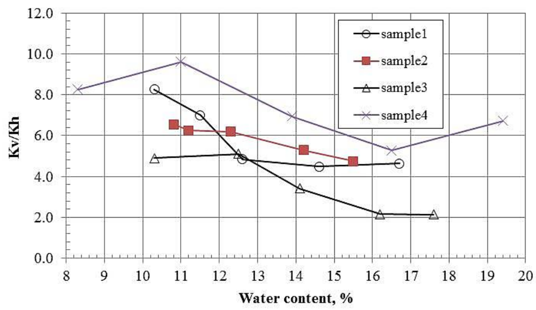

Figure 4 Permeability direction ratio (K_v/K_h) of four compacted soil samples

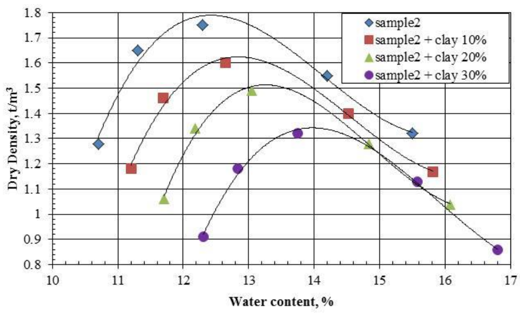

Figure 5 Compaction curve of soil sample2 mixed with various clay contents

The K_h value is quite constant at the wet side of optimum compaction in the range of $4x10^{-8}$ to $1x10^{-6}$ cm/sec. The K_v value is higher than K_h value. The permeability direction ratio (K_v/K_h) was plotted at various water content as showed in Figure 4. The K_v/K_h value decreases when the water content of the compacted soil increases. The K_v/K_h value is in the range of 2-7 when the water content is higher than the optimum water content.

Figure 5 shows the compaction cure of soil sample2 mixed with clay content with percentages of 0, 10, 20 and 30 per weight of dry soil. The optimum water content of compacted soil increases when the clay content was mixed. The maximum dry density of the compacted soil decreases with the increasing of clay content.

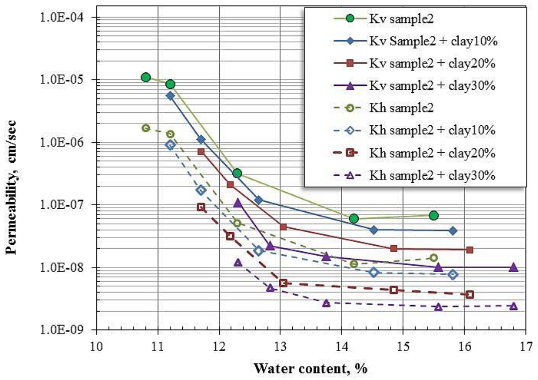

Figure 6 Permeability of soil sample2 mixed with various clay contents

Figure 6 shows that the K_h and the K_v values of compacted soil are reduced when the clay content increased. The permeability of compacted soil is quite constant when the water content is higher than the optimum water content. The permeability of compacted clay at the relative compaction in the rage of 85 to 90 percent is nearly constant. It found that the K_v and K_h of compacted soil sample2 decreased about 30, 65 and 83 percent with increasing percentage of clay content 10, 20 and 30, respectively. It is clearly showed that the increasing in the clay content is especially subject to decrease in the K value by 80 percent. It can be stated that the mixing clay content in the compacted soil can be improved the performance of compacted lateritic soil for the water protection system.

4. Conclusions

The K values sharply decrease when the dry density increases until the maximum dry density. Then they are nearly constant at the relative compaction less than 85% with the water content higher than optimum water content. The K_v/K_h decreases when the water content of the compacted soil increases. The K_v/K_h value is in the range of 2-7 when the water content is higher than the optimum water content. The K value of compacted soil is reduced when the clay content increased. The increasing in the clay content is especially subject to decrease in the K value by 80 percent.

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