Effects on Collapsible Sandy Soils in Double Consolidation Test

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Introduction

There are different types of soils found in nature which collapse under certain conditions. These soils can be broadly divided into two group; namely wet collapsible soils and dry collapsible soils as also known as hydrocollapsible soils. Wet collapsible soils such as quick clays can exist in a stable condition under high in-situ water contents [1]. One method of including the basic soil types in a single figure is to use a flow chart, or tree, of collapsible soils, such as that shown in Figure 1 and one of the most popular methods to identify the collapsible soil is the double consolidation test

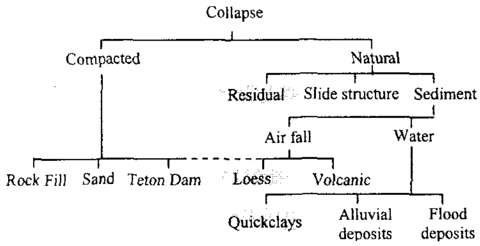

Fig 1. A classification of collapsible soil [2]

Almost soils in Northeast Thailand, especially loess, pose problems to the engineering works on or with these soils because they are easily erodible, collapsible and dispersive. Its properties lead to uncertain design and construction. Most of civil engineers in Thailand hesitate to use loess as construction materials. Therefore, the subject of collapsible soils has been, perhaps necessarily, approached from individual disciplines and from many researchers. To deal with proving such those problems in Thailand, a study of the collapsibility of soil is necessary for material selection. This research deals only with the uncemented, dry collapsible soils. As shown in Figure 1, the "Shirasu", volcanic sandy soil was remolded by static compacted method. Due to the fact that the Khon Kaen soil is also sediment by wind, the "Shirasu" soil can be used to study the mechanism of collapsible soil and to improve collapsible potential of the Khon Kaen loess

A mechanical disturbance which induces a shear stress is the triggering mechanism in the collapse of wet collapsible soils. The collapse occurs with no change in the water content of the soil. The triggering mechanism in uncemented, dry collapsible soils is attributable to loss of strength due to reduction in matric suction as a result of wetting. In the other words, an uncemented, dry collapsible soil collapses when there is a change in the stress state of the soil as it goes from an unsaturated condition towards a saturated condition.

Collapse Index

The single and double consolidation tests have been performed to investigate collapse behavior of compacted soil in term of collapse index (I_c). The collapse index can be calculated by the following equation:

$$I_c = \frac{100\Delta e}{1+e_0} = \frac{100\Delta h}{h_0} \tag{1}$$

where Δe and Δh are the changing of void ratio and sample height due to inundation; e_0 and h_0 are initial void ratio and initial sample height before inundation.

Experimental Program

A laboratory test program was conducted to study the collapse of a statically compression of volcanic sandy soil, Shirasu soil in Japan. The index properties of Shirasu soil are shown in Table 1. The tests were conducted to verify the effort of collapse in Shirasu soil and to study the effects of initial dry density, initial water content, vertical stress for soaking and soaking pressure on collapsibility.

Table 1 Index properties for Shirasu soil

Property	Shirasu
Specific gravity	2.54
Grain size distribution	
Sand	85%
Silt	13%
Clay	2%
Water content	0.6%-1.3%
Optimum moisture content	8.1%
Maximum dry density	1.44 g/cm^3
γ_{dmin}	0.954 g/ cm^3
γ_{dmax}	1.297 g/ cm^3

Test Procedures

The collapse tests were conducted in a conventional oedometer. In each test, the specimen was placed between two air dry porous stones and filter papers in the oedometer ring. The preparation of the specimens depends on the design initial water content and degree of relative density. To reconstitute, it was statically compacted to the design condition before doing consolidation test. The maximum stress history can be found from the relationship between void ratio and vertical stress applied.

Keywords: Unsaturated Soil, Collapsible Soil, Double Consolidation Test, and Collapsible Potential
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In the consolidation process, the specimen was loaded every two hours by doubling the previous load. When settlement under the applied load completed, the specimen was inundated with distilled water. Subsequent to saturation of the specimen for 24 hours, further loads were again applied to the specimen under saturated conditions.

Results and Discussions

A summary of the results of tests are presented in Figure 2 to Figure 5. The results of changing in void ratio with vertical load in Figure 2 are for specimens inundated at various vertical loads. As can be seen that the changing in void ratio due to inundation could be predicted using the double consolidation approach quite well comparing to dry and wet line of consolidation curve. The results also show that the void ratios of the initially unsaturated specimens approach the consolidation line of the saturated specimen after being subjected to the inundation.

The experimental results clearly indicate that the total volume of the specimen started decreasing when it changes from the unsaturated to saturated condition. The volume of specimen continues to decrease until it reaches the saturated condition.

For the wetting history, the potential of collapsibility is high when soaking near the maximum stress history of specimens as shown in Figure 3. Figure 4 shows the relationship between initial void ratio and maximum stress history that relates to Figures 2 and 3. As well, it shows that the Shirasu soil has a moderate to moderately severe degree of collapse.

In term of the effect of initial water content as shown in Figure 5, it shows that increasing in initial water content decrease the collapsible potential. It is one reason to confirm that the collapsibility will be finished when the water added until reaching the saturated condition.

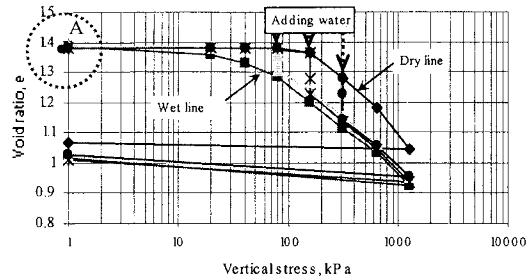

Fig 2. Effect of soaking pressure on the collapsibility (Dr = 20%)

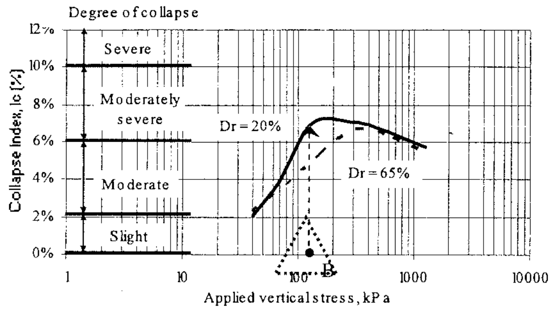

Fig 3. Effect of location of soaking relating to stress history

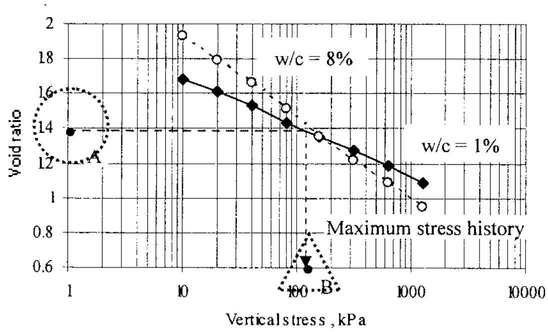

Fig 4. Relationship between void ratio and vertical stress

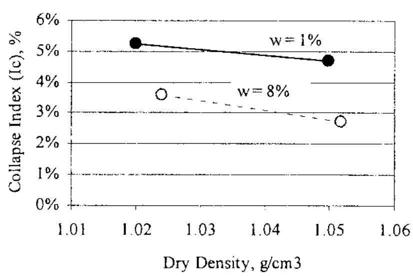

Fig 5. Effects of initial water content

Conclusions

1. The void ratio changes due to inundation could be predicted using the double consolidation approach quite well. Shirasu soil can be presented as moderate to moderately severe collapsible soil.
2. Void ratios of the initially unsaturated specimens approach the consolidation line of the saturated specimen after being subjected to inundation
3. The maximum potential of collapsible usually occurs nearly the point where maximum stress history occurred at the point of preloading in this case.
4. The higher initial water content, the lower potential of collapsibility.

[Reference]

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