Effect of Initial Void Ratio on Collapse of Compacted Clay

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In the paper published last year (Sun, et al. 2001), the influences of some factors including initial water content, initial density and stress state on the collapse of compacted clay have been preliminarily studied. In this study, by using suction controllable triaxial apparatus for unsaturated soils, a series of triaxial tests on compacted clay are performed to investigate in detail the influence of the initial void ratio on collapse behavior of compacted clay.

1 Testing program

1.1 *Testing material and specimen preparation.* The used soil is pearl clay with a liquid limit of 49 and a plasticity index of 27. The grain-size distribution curve indicated that the soil is composed of clay size of about 50% and silt size of about 50%. The clay mineralogy compositions, determined using X-ray diffraction, are quartz, pyrophyllite, and kaolinite in the dominant order. There is little expansive clay mineral in pearl clay. Triaxial specimens, 3.5cm in diameter and 8.0cm high, were prepared by compaction in a mould at water content of about 26%. Specimens were compacted in five layers, with each layer statically compacted at the same number using a 1.2cm diameter plunger up to a vertical stress of 314kPa.

1.2 *Triaxial tests for unsaturated soils.* Tests were conducted in the improved triaxial apparatus that can measure directly the lateral strain of specimens and control matric suction. The lateral displacement was measured by using two rings made of stainless steel mounted at H/4 and H/2 from the top. The pore-water pressure was maintained to be atmospheric during test through a ceramic disk installed in the pedestal, with the air entry value of 300kPa, while the air pressure was applied at the top through a polyfluortetraethylene filter, which can prevent water from seeping. Hence, the change in the water amount of the burette is the same as the change in the water amount of the specimen.

1.3 *Testing procedures.* The specimens were first isotropically consolidated at a total stress p_t of 20kPa with an initial suction of about 100kPa, and then a specific air pressure was applied to specimens with a net stress p of 20kPa in isotropic stress, where the net stress $p=p_t-u_a$, u_a=pore-air pressure. After that the drain valve was opened for achieving the pore-water pressure $u_w=0$. The specimens were thereby loaded to an expected stress state under a constant suction, and subsequently the imposed suction was decreased in a drained mode for performing collapse test. In the collapse test, the de-aerated water stored in the burette was introduced from the bottom of the specimen through the ceramic disk. For most of tests, triaxial tests on saturated specimens up to failure were performed after collapse tests.

2 Triaxial testing results

2.1 *Effects of mean stress and initial void ratio on collapse in isotropic stress.* Figures 1(a) and (b) show the results of the isotropic compression and collapse tests on compacted clay with (a) e_{0a}=1.36 and (b) e_{0a}=1.27, respectively. Here e_{0a}=the average initial void ratio of the tested specimens. The volume change behavior of compacted clay was obtained by the isotropic compression tests during constant matric suction of 147kPa, decreasing matric suction from 147kPa to 0kPa and zero matric suction. The identically compacted specimens shown in Fig. 1(a) or (b) respectively were loaded under the suction of 147kPa from the initial state (p_t=20kPa and s 100kPa), and then successively increased the isotropic stresses and allowed to attain equilibrium at each level of stress. The plots around p=20kPa in Figs. 1(a) and (b) show the decrease in the

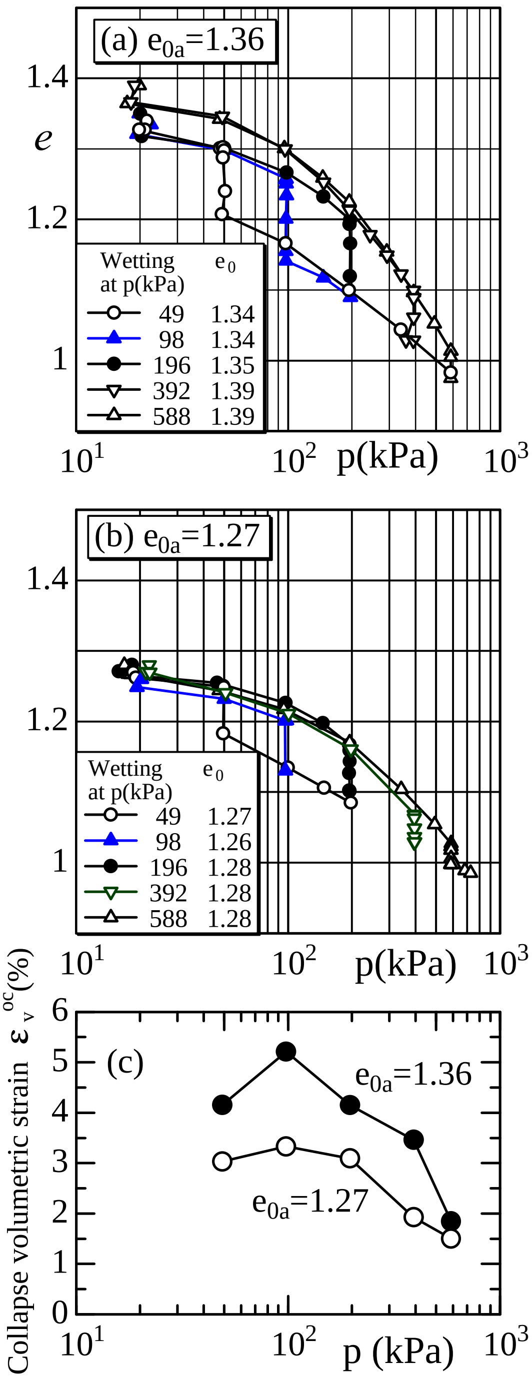

Fig.1 Volume change of compacted clay in isotropic stresses including wetting

void ratio due to the suction increase from s 100kPa to 147kPa. From the compression curves with the suction of 147kPa, the yield stresses were about 100kPa for the specimen with e_{0a}=1.36, and about 150kPa for the specimen with e_{0a}=1.27. After the specimen was isotropically loaded under a previously specified net confining pressure and a constant suction of 147kPa, the specimens were allowed to consolidate at various steps of decreasing the suction from 147kPa to 0kPa. Figure 1(c) shows the collapse strains at different isotropic stresses at which the imposed suction were decreased from 147kPa to zero. The collapse volumetric strain is defined as

$$\varepsilon_v^{co} = \frac{-\Delta e_{co}}{1+e_b} \qquad (1)$$

where e_b is void ratio at the start of suction reduction, and Δe_{co} is difference of void ratios before and after suction reduction. From Fig. 1, we can see that the magnitude of volume change, due to the decreasing matric suction, depends on the mean net stress and initial void ratio, and there is a maximum collapse at some net stress for the identically compacted specimens. After the yield stress, the greater is the net stress, the smaller is the magnitude of the collapse due to decreasing the imposed matric suction. The compression curves for saturated and unsaturated soils with constant suction converge at a point where no collapse occurs when the suction is decreased. For the tested specimens, the magnitude of the collapse is very small in the range of the high stress, e.g. p>500kPa, and is very large in the range of the ordinary stress, e.g. p<200kPa. The compression curves of the specimens with zero suction are almost the same after the collapse takes place in different stresses and initial void ratios, as shown in Fig.2. These collapse behaviors can be predicted by our elastoplastic model for unsaturated soils(Sun et al. 2000).

2.2 *Effect of initial void ratio and stress ratio on collapse in anisotropic stress.* Figures 3 (a) and (b) shows the stress versus strain relations of the specimens, compacted using the samples of the same water content (w 26%) by different compaction numbers, obtained from triaxial compression tests during a constant suction of 147kPa, decreasing in the suction from 147kPa to 0kPa at the principal stress ratios of 1.5 and 2.0 and zero suction under mean stress of 196kPa. Figure 3(c) shows the collapse as a function of the initial void ratio of the specimen rearranged from Figs.1 (a) and (b) and Figs.3 (a) and (b). It can be seen that the smaller is the initial void ratio of the specimen, the smaller is the magnitude of the collapse due to decreasing suction irrespective of the stress ratio at which the suction is decreased. That is to say, under the same initial matric suction, the looser is the specimens, the larger is the collapse due to decreasing the suction. The points(∇) shown in Figs.3 (a) and (b) show the results of the tests on specimens with the initial void ratios of 1.15 and 1.08. The specimen volume contracts firstly and then dilates rather than only contracts during shear process. This means the compacted clay specimens with the same matric suction may have different dilatancy behavior even under the same mean net stress.

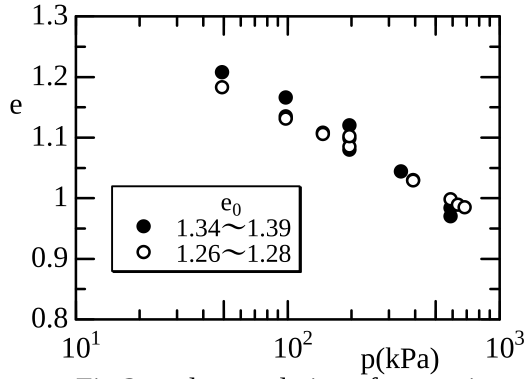

Fig.2 e〜log p relation after wetting

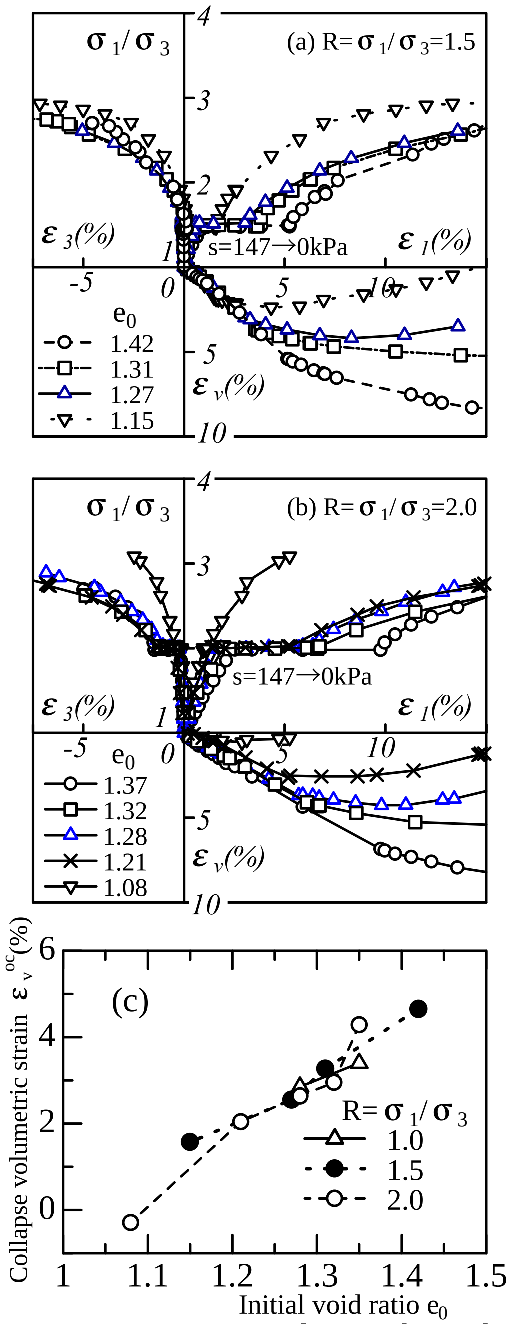

Fig.3 Stress vs. strain relations obtained from triaxial tests inluding collapse tests (p=196kPa)

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