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Stress-strain Behavior of Remolded Clay from Intermediate Principal Stress Controlled Tests

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This experimental study aims at investigating the effect of intermediate principal stress on stress-strain behavior, pore water pressure generation and strength characteristics of a remolded clay through the use of the cubical triaxial testing apparatus designed by P. V. Lade to permit application of 3 unequal principal stresses to a cubical specimen with 7.6-cm side lengths. The specimen is contained between a cap and base plates which have been lubricated and a horizontal loading plate. The clay sample used in this study came from Kwang-Yang Bay and was remolded and reconsolidated over 3 months in a consolidation container. It was found that the ratio of effective stress (σ_1'/σ_3') and the normalized pore water pressure (u/σ_c) at failure increase for b [$= (\sigma_2 - \sigma_3/(\sigma_1 - \sigma_3)$] values ranging from 0 to 0.4 and remain almost constant for b values larger than 0.6. The state of stress of Kwang-Yang clay on the triaxial failure plane as well as the octahedral plane shows that the intermediate stress has an effect on 3-dimensional failure behavior.

INTRODUCTION

In conventional triaxial tests, in which specimens are cylindrical, the state of stress is axisymmetric. This that, because the value of σ_2 in conventional TX tests is restricted, its effect cannot be studied. In other words, since the state of stress is $\sigma_1 > \sigma_2 = \sigma_3$ in the conventional triaxial compression test, and $\sigma_2 = \sigma_3 > \sigma_1$ in the conventional triaxial extension test, the intermediate stress is always equal to the major or minor principal stresses. At the same time, numerous studies have noted that intermediate principal stress can have a significant effect on soil behavior. Since the 1950s, a few attempts have been made to investigate the effect of intermediate principal stress on soil behavior. Ko and Scott (1967), Green (1971), and Sutherland and Mesdary (1969), for example, developed new testing apparatuses that could control each principal stress independently in order to study the behavior of sandy soils. Lade (1979) showed by cubical triaxial tests that intermediate principal stress has an influence on the stress-strain behavior and strength characteristics of sands. The cubical triaxial testing apparatus originally designed by Lade (1979) has been widely used. So far, most studies using the cubical triaxial tests have focused on the behavioral and strength characteristics of sands. In fact, Henkel (1960) presented the result of the cubical triaxial tests on clayey soils. Yet, little research has been carried out on clayey soils (Nakai et al., 1986; Kirrgard et al., 1993; Prashant et al., 2004, 2005). In this study, the effects of intermediate principal stress on a clayey soil were investigated using the cubical triaxial testing apparatus designed by Lade. A series of experimental tests was conducted at 5 different confining pressures and 5 different intermediate principal stress ratios, b [$= (\sigma_2 - \sigma_3/(\sigma_1 - \sigma_3)$]. The results were compared with those from conventional triaxial tests that were performed at $\sigma_2 = \sigma_3$ in the cubical triaxial device. From the test results, it was concluded that intermediate principal stress has great influence on the stress-stain behavior, effective stress, pore water pressure, undrained shear strength and effective internal friction angle of normally consolidated clayey soil, especially for Kwang-Yang clay.

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EXPERIMENT

Material

The specimens used in this study were prepared from clay sampled from Kwang-Yang Bay in Korea. Due to the difficulty in obtaining undisturbed specimens in situ, all specimens were remolded and prepared artificially in the laboratory. Once the clay was delivered to the laboratory, it was consolidated under 49 kPa pressure in a consolidation container over 3 months. In this step, only soil-passing sieve No. 120 was used. Table 1 lists Kwang-Yang clay properties.

Testing Apparatus

The cubical triaxial testing apparatus was originally designed by Lade (1979). The specimen, which is contained between a cap and base and surrounded by a membrane, is 7.6 cm × 7.6 cm × 7.6 cm (Fig. 1). The stainless-steel cap and base, 10 cm × 10 cm, allow the specimen to expand up to 30% when subjected to an axial load. The 0.03-cm-thick membrane surrounding the specimen is of rubber; it was tightened by a rubber O-ring. The intermediate principal stress (σ_2) was generated through the use of a special loading device (Fig. 2); it consists of 2 plates, placed on opposite sides of the specimen and interconnected to supply compression to it. Fig. 3 shows the balsa wood attached to the horizontal loading device.

Properties	Wn(%)	Gs	LL(%)	PL(%)	PI(%)	USCS
	51.6	2.68	56.0	29.0	27.0	CH

Table 1 Physical properties of Kwang-Yang clay