Discussions and Closures

Discussion of “Elastoplastic Deformation Characteristics of Gravelly Soils” by Meng-Chia Weng, Bin-Lin Chu, and Yu-Ling Ho

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The authors are commended for exploring the elastoplastic deformation behavior of gravelly soils though a series of large-scale triaxial compression tests. They concluded that (1) the elastic shear modulus increases with increasing hydrostatic pressure, (2) the influence of confining pressure on plastic deformation is insignificant, (3) gravelly soils follow the nonassociated flow rule, and (4) the plastic potential surface contains an approximate horizontal line and an elliptical surface. The discussers agree with these conclusions except for the second conclusion. Granular soil may show volumetric expansion at a smaller confining pressure and it may present volumetric contraction behavior at a higher confining pressure because of high particle breakage. Therefore, the confining pressure may lead to a variation in the deformation style (i.e., expansion or contraction) of granular soils.

The discussers hold the view that plastic deformation is greatly influenced by confining pressure. To prove this point, the results of a series of large-scale triaxial compression tests on Tacheng rockfill material (TRM) (Jiang 2009) were used.

Test Introduction of Rockfill Material

Tacheng rockfill material from the Jinsha River in China was used for testing (Jiang 2009). The maximum particle size of the TRM in this test was 60 mm. The TRM shape was rounded and sub-rounded. Fig. 1 shows the initial particle size distribution of the TRM. The specimen size was set at 300 mm in diameter by 600 mm long. The TRM was divided into five equal parts for compacting inside the split mold. The TRM specimen was consolidated by the initial confining pressures (i.e., \( p_0 = 0.4 \) MPa, 0.8 MPa, and 1.6 MPa, respectively). The TRM specimen under the drained condition was then sheared with a constant axial strain rate of 1.5 mm/min. The axial strain reached 15% before the test was stopped, because at this point the critical state of TRM was supposed to be reached.

Test Results on Plastic Deformation of Rockfill Material

Fig. 2 shows the relationship between the plastic volumetric strain and the plastic axial strain of the TRM with different initial confining pressures. The TRM shows a marked positive dilatancy behavior (i.e., a volumetric expansion behavior) at a lower initial confining pressure (i.e., \( p_0 = 0.4 \) MPa), whereas it exhibits a negative dilatancy behavior (i.e., a volumetric contraction behavior) at a higher initial confining pressure (i.e., \( p_0 = 1.6 \) MPa), as shown in Fig. 2(a), with the initial void ratio equal to 0.189. In addition, the dilatancy behavior at a lower initial confining pressure tends to diminish and the volumetric contraction behavior at a higher initial confining pressure tends to become enlarged when the initial void ratio of the rockfill material is increased.

Fig. 3 illustrates the influence of the initial confining pressure on the relationship between the stress ratio and the plastic volumetric strain of the TRM. A highly positive dilatancy behavior in the process of shearing is observed at a lower initial confining pressure (i.e., \( p_0 = 0.4 \) MPa), whereas a negative dilatancy behavior in the process of shearing can be found at a higher initial confining pressure (i.e., \( p_0 = 1.6 \) MPa), as shown in Fig. 3(a). An increase in the initial void ratio would increase the degree of influence of the initial confining pressure on the volumetric contraction behavior of the TRM. In contrast, an increase in the initial void ratio would attenuate the degree of influence of the initial confining pressure on the volumetric expansion behavior of the TRM. Therefore, the initial confining pressure has a great influence on plastic volumetric strain.

Other Test Results of Rockfill Material and Railway Ballast

Monotonic (Anderson and Fair 2008; Indraratna et al. 1998; Varadarajan et al. 2003) and cyclic (Anderson and Fair 2008; Lackenby et al. 2007) test results of rockfill material and railway ballast also show that the confining pressure has a great influence on the plastic deformation of rockfill material and railway ballast. A larger confining pressure would lead to more particle

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Fig. 1. Initial particle size distribution of TRM (data from Jiang 2009)
breakage; more particle breakage would result in more volumetric contraction.

**Test Results of Gravelly Soils from the Original Work**

The authors did not apply the test results on the volumetric strain with different confining pressure, as shown in Fig. 5 in the original work. It would be difficult to determine the influence of the confining pressure on the plastic deformation. The influence of the confining pressure on the plastic strain trajectory would be insignificant, as shown in Fig. 12 in the original work. However, it would still be unwise to conclude with certainty that the influence of the confining pressure on the plastic deformation of gravelly soils is insignificant.

**Conclusions**

Based on a series of large-scale triaxial compression tests of rockfill material (Jiang 2009) and other test results on rockfill material and railway ballast by Indraratna et al. (1998), Varadarajan et al. (2003), and Anderson and Fair (2008), the discussers maintain that plastic deformation is greatly influenced by confining pressure.
Fig. 3. Stress ratio versus plastic volumetric strain of TRM: (a) $e_0 = 0.189$; (b) $e_0 = 0.244$; (c) $e_0 = 0.285$; (d) $e_0 = 0.317$ (data from Jiang 2009)

References

