A Consideration on Bearing Capacity for Evaluation Method of Diatomaceous Soft Rock

Tokai University Student Member ○Dyah Sri Utami
Tokai University Regular Member Motohiro Sugiyama

1. Introduction

According to Terzaghi's bearing capacity formula, the coefficient of bearing capacity and bearing capacity differ depending on the failure mode of the ground (general shear failure, local shear failure)[1),2)], and the relationship between the load and the amount of footing settlement in both failure modes is classified by state of the soil condition (coarse / dense, hard / soft). In general shear failure, it is assumed that all points on the slip surface reach the ultimate state at the same time, whereas in local shear failure, the point where the ultimate state is reached increases with increasing load, and it is formed that the slip surface is expanded by progressive fracture. Therefore, it is necessary to determine the failure mode to calculate the bearing capacity of the ground, but the criterion has not been clarified so far. The stress-strain relationship of soil is classified into a strain softening type and a strain hardening type, and the bearing capacity problem is considered to correspond to general shear and local shear failure modes.

Diatomaceous soft rock is a material that shows remarkable strain softening irrespective of consolidation state[3)]. In evaluating the bearing capacity of this rock, it is reasonable to consider that the shear stress at the point where the shear stress locally reaches the shear strength according to the strain level before reaching the ultimate bearing capacity (q_d) decreases to the residual strength. However, the mechanical behavior after the peak shear strength has not been sufficiently investigated.

This research examined the shear strength and bearing capacity of diatomaceous soft rock by laboratory tests. The effect of the diameter of the specimen on the bearing capacity of a 3.5 cm diameter circular footing was investigated, and the relationship between the shear strength obtained from the triaxial compression UU test and the results of the bearing test was discussed.

2. Samples and experimental methods

The sample is a homogenous diatomaceous earth (diatomaceous soft rock) collected in block form in Suzu City, Ishikawa Prefecture. Table 1 shows the physical properties of the samples. Specimen height (h) was fixed at 10 cm and diameter (d) was selected as 3.5, 5.0, 7.5, 10, 15, 30 cm and a stainless steel footing with a rough bottom with a diameter of 3.5 cm and a bearing capacity test with a shear rate of 1.0 mm/min. Fig. 1 shows the test specimens, and Fig. 2 shows the view of the bearing capacity test conducted at 30 cm in diameter.

Table 1 Physical properties of samples

ρ_s (g/cm³)	ω_n (%)	ω_L (%)	ω_p (%)
2.183	120～130	172.7	94.7

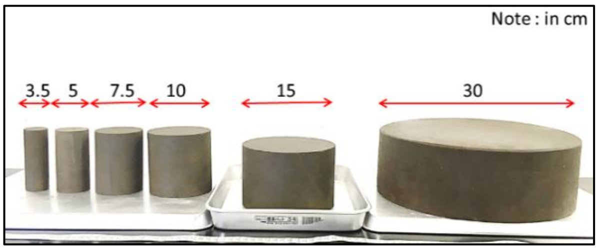


Fig.1 Test specimens

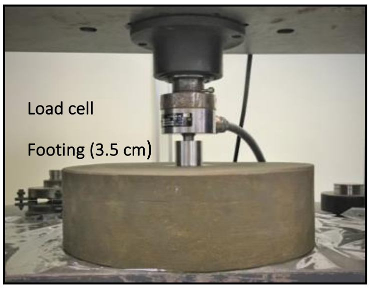


Fig.2 Test specimens 30 cm diameter

3. Experimental results and discussion

3.1 Triaxial UU test results

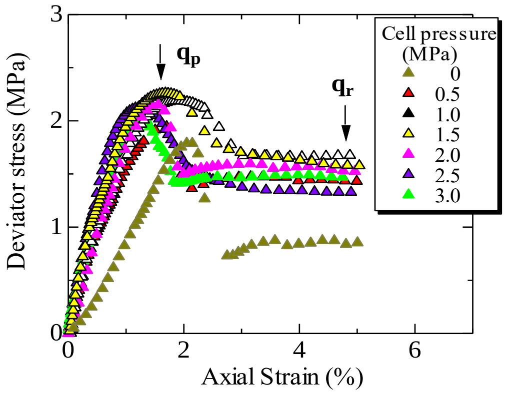
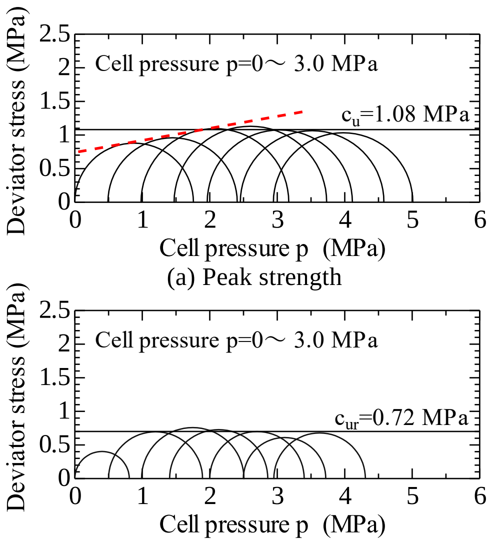


Fig. 3 Stress-strain relationship in triaxial UU

Fig. 3 shows the stress-strain relationship of the triaxial UU test. The result of zero cell pressure is different from the other test results even though it was performed as a UU test instead of unconfined compression test. The other maximum deviator stress, which is called as peak strength (q_p) is 2.1 to 2.2 MPa regardless of the cell pressure, and the axial strain at that time is approximately equal to 1.5%. Furthermore, it shows that the sample exhibits remarkable strain softening behavior, which is a characteristic of this sample, and all of them reach almost the same residual deviator stress, which is called as residual strength (q_r). Therefore, Fig. 4 shows the Mohr's circles based on the peak strength and the residual strength, and the fracture envelope of $\varphi_u = 0$ can be drawn in the same way as observed

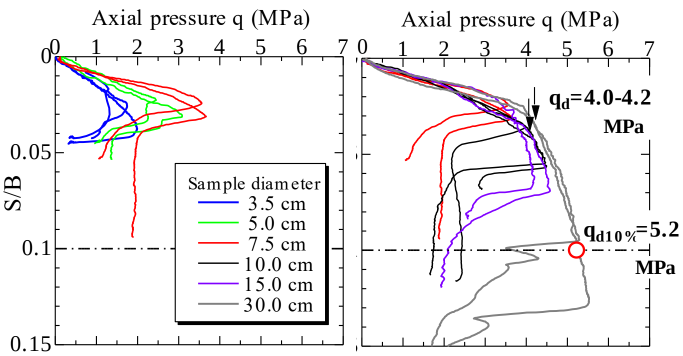
Keywords: Diatomaceous Soft Rock, Triaxial UU Test, Bearing Capacity, Strain Softening, Residual Strength
Contact address: 4-1-1 Kitakaname, Hiratsuka-shi, Kanagawa 259-1292, Tel: 0463-1211, E-mail: dsutami95@gmail.com



(a) Peak strength

(b) Residual strength

Fig. 4 Mohr's circles for triaxial UU



(a) 3.5-7.5 cm in diameter (b) 7.5-30 cm in diameter

Fig. 5 q-S/B curve of bearing capacity test

with saturated clay except for zero cell pressure. Undrained shear strength (c_u) is 1.08MPa. The residual strength (c_{ur}) is 0.72MPa, which is about 70% of c_u. The ultimate bearing capacity (q_d) based on some bearing formulas using these values is compared with that obtained from the bearing test in next section.

3.2 Results and discussion of bearing capacity test

Fig.5 shows the relationship between the axial pressure and the settlement ratio (settlement S / footing width B) of samples having different diameters. The peak drop shape shown in Fig. 3 is shown up to 7.5 cm in diameter, in Fig. 5 (a), but the yield point is confirmed when the diameter exceeds 10 cm. In the test under these conditions, it was confirmed that the diameter of the test specimen, for evaluating the bearing capacity equal to or higher than the yield stress must be at least three times the footing diameter. The ultimate bearing capacity (q_d) of the experimental results with a diameter of 10 cm or more according to the determination method in Fig.6 was 4.0 to 4.2MPa. In the classic bearing formula under the test conditions, q_d is 5.1c_u to 6c_u. Substituting the c_u value of the UU test into this equation, q_d is 5.5 to 6.6 MPa, which is about 60% larger than the measured value.

Therefore, using the c_{ur} value obtained from the residual strength (q_d) was 3.7 to 4.4MPa, which was close to the measured value. The red circle in Fig. 5(b) indicates that the q_d value at S/B=10%, which is a method for judging the ultimate bearing capacity by a plate bearing test, was read and 5.2 MPa

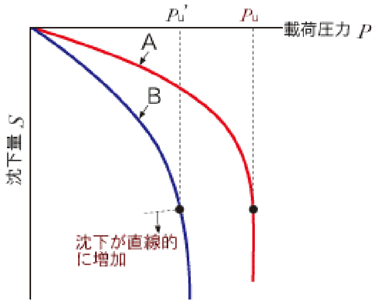
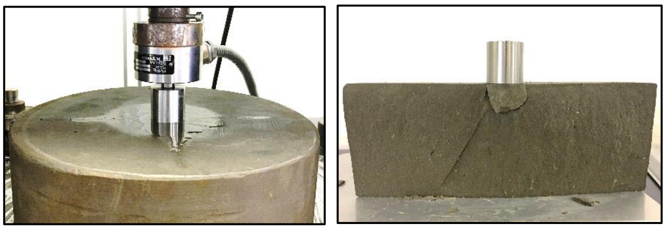


Fig. 6 Determination method for the q_d



(a) Water floating during the test (b) Wedge formed under the footing

Fig. 7 Bearing capacity test with a diameter of 30 cm

was obtained. $q_{d10\%}$ indicated by the red circle in Fig.5 (b) is the q_d value when S/B=10%, which is a method for determining the ultimate bearing capacity by the plate loading test and the value was 5.2MPa. This value corresponds to the lower limit of the bearing capacity formula based on the c_u value.

Fig. 7 shows the sample that was broken during the test and that was split into two parts. It can be seen that the range of failure is about 3 times the footing diameter and that a wedge is formed under the footing.

4. Conclusion

The bearing capacity of diatomaceous soft rocks showing remarkable strain softening behavior was examined by the plate bearing test of specimens with different diameters. As a result,

1. In order to obtain the ultimate bearing capacity, the specimen diameter must be at least three times the footing width,
2. It is shown that the ultimate bearing capacity of this sample calculated by the bearing capacity formula is better to utilize the residual strength (c_{ur}) of UU test.

References

C.H.Dunn : Bearing Capacity of Soil, Manuals Corps of Engineers, U.S Army, 1958.

K. Miyakita and H. Maekawa : Mechanical properties of diatomaceous soft rock (diatomaceous earth) in Noto peninsula, Soil mechanics and foundation engineering, 31(1), pp.83-88, 1983. (Japanese text)

Terzaghi, K. : Theoretical of Soil Mechanics, Willey, New York, 1943.