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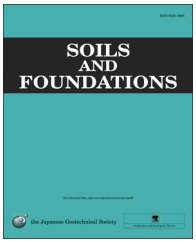

Mechanical characteristics of reconstituted coral gravel soils with different fractions of finger-coral fragments and silt matrix

Yoichi Watabe[a,*], Shinji Sassa[b], Takashi Kaneko[a], Yukio Nakata[c]

[a]*Soil Mechanics and Geo-environment Group, Port and Airport Research Institute, 3-1-1 Nagase, Yokosuka 239-0826, Japan*
[b]*Soil Dynamics Group, Port and Airport Research Institute, 3-1-1 Nagase, Yokosuka 239-0826, Japan*
[c]*Department of Environmental Geotechnical Engineering, Yamaguchi University, 2-16-1 Tokiwadai, Ube 755-8611, Japan*

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Abstract

Coral gravel soils, which are composite soils consisting of finger-coral fragments and silt matrix, are often found in coastal regions of sub-tropical islands. In this study, for reconstituted soils with various volumetric percentages of coral fragments up to 44% (coral particle fraction of 59%) as the densest package, a series of triaxial CU-bar and CD tests was conducted to study the determination method for the soil design parameters in consideration of the interaction between the soil skeleton, consisting of coral fragments, and the silt matrix. For samples with volumetric percentages of coral fragments less than 20% (coral particle fraction of 31%), the shear strength obtained from the CD tests was slightly larger than that obtained from the CU-bar tests; however, the difference between the two tests was very small. For samples with volumetric percentages of fragments more than 20% (coral particle fraction of 31%), the shear strength obtained from the CU-bar tests was significantly overestimated because of the unrealistically large negative excess pore pressure in the field corresponding to significant dilation. The shear strength obtained from the CD tests also showed a similar tendency corresponding to volume expansion; however, these values are much smaller than those obtained from the CU-bar tests. For the samples with a dense package of coral fragments, shear resistance angle ϕ was much larger than that for normal soils; however, it tended to decrease in association with the particle crush of coral fragments. The tendency of the particle crush was visually evidenced through CT-images taken before and after the triaxial tests. The soil parameters were significantly influenced by the volumetric percentages of the coral fragments in association with particle interaction and particle crush, when the percentage was more than 20% (coral particle fraction of 31%) for the coral gravel soils examined in this study.

Keywords: Coral gravel soil; Coral fragments; Silt matrix; Particle crush; Mechanical properties; Triaxial test

1. Introduction

Coral gravel soil is a composite soil consisting of finger-coral fragments and silt matrix. In the case of a small content of coral fragments, the mechanical behavior is governed by the silt matrix, but in the case of a large content of coral fragments, the behavior is governed by the coral fragments. Generally speaking, in geotechnical engineering, cohesion parameter c is used to evaluate the undrained shear strength of soils with low permeability, while angle of shear resistance ϕ is used to evaluate the drained shear strength of soils with high permeability. For coral gravel soils; however, it has not yet been clarified how to determine soil parameters c and ϕ in design practice. The intrinsic mechanical performance of coral gravel soils has not been studied because it is difficult to collect undisturbed samples of these coral fragments. Coral gravel

*Corresponding author.
E-mail address: watabe@ipc.pari.go.jp (Y. Watabe).
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soils are often found in coastal regions of sub-tropical islands, such as the Ryuku Islands in Japan. In those regions, coral gravel soils have caused geotechnical issues for the above reasons.

At construction sites in coastal regions of Okinawa, Japan, soil sampling has been conducted using conventional samplers such as the thin-walled tube sampler with a fixed piston (JGS-1221) and the rotary type of double-tube sampler (JGS-1222). Soil samples collected from a construction site along a shore road (Fig. 1) by the conventional rotary type of double-tube sampler are shown in Photo 1. Coral gravel soils were found from the surface to a depth of 8 m, and a lime rock layer was found below this depth of 8 m that partially included some coral gravel soils. As the edge of the sampler dragged the coral fragments while coring the samples, the collected soil samples were significantly disturbed. This sample disturbance is one of the reasons for the difficulties in evaluating the mechanical properties of coral gravel soils.

Due to the difficulty of soil sampling, the mechanical properties of coral gravel soils have not been well studied. Although they are not coral gravel soils, some research works on composite soils consisting of a clay matrix with sand–gravel particles have been reported. Fragaszy et al. (1990) modeled the variation in soil bulk density by considering the contact effect between gravel and fine clay particles. Fragaszy et al. (1992) and Simon and Houlsby (2006) evaluated the shearing characteristics of composite soils consisting of sand and gravel particles. These studies focused on the grain-size distribution for laboratory testing, which is prepared as either a proportionally reduced grain-size distribution to the original grain-size distribution or a finer fraction of the original grain-size distribution sieved by a certain maximum grain-size, if

Fig. 1. Coastal region in Urasoe City, Okinawa, Japan, where abundant coral gravel soils were found.

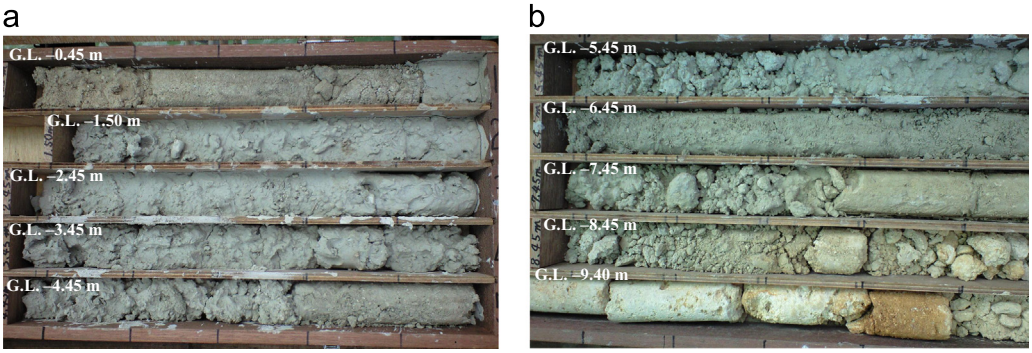

Photo 1. Soil samples collected by a conventional sampler: (a) G.L. –0.45 to –5.45 m and (b) G.L. –5.45 to –10.40 m.