Multi-wave X-ray micro-CT study on bicontinuous hybrid materials.

Yukihiro Nishikawa (3679), Hiroshi Jinαι (3670), Taishi Hashimoto (13782)

Department of Polymer Sci. and Eng., Kyoto Institute of Technology, Matogasiki, Sakyuu, Matsugasaki 606-8585, Japan

Elemental density map of the sample was determined in three-dimensional space by multi-wavelength X-ray computer tomography (CT) without using absorption edges of the elements. This method can be applied for any elements, and can simultaneously determine the densities for all constituent elements in the sample. In previous studies, we applied this method to the determination of Ca density in trabecular bones. But the reliability of the data was not critically tested. In this study, we used brominated polystyrene (BrPS) as a model sample. The bromide density was determined by three ways; mass analysis, anomalous absorption edges for X-ray, and multi-wavelength method.

The BrPS was prepared by the chemical addition of bromine to polystyrene. The introduction ratio was 28 bromines to 100 styrene monomer units determined by organic elemental microanalysis method. The total density of BrPS was also measured as 1.214 g/cm³ by pycnometry. Thus, the density of bromides is 0.197 g/cm³.

Bromine has an absorption jump at 13.49KeV (L-edge). It is ordinary method to determine the density by using this absorption jump. Thus obtained density of bromides was 0.197 g/cm³.

Figure 1 shows the bromides density map obtained by multi-wavelength X-ray CT. The density at the uniform grey scale region in Figure 1 gave 0.200g/cm³. This value agreed with the value from L-edge and also agreed with that of organic elemental microanalysis in 5% errors.

Mechanics of granular materials is used in various engineering fields such as geotechnical engineering and powder engineering. Within a quasi-static regime, a granular assembly stands against an external force by constructing a contact-force network. Therefore it is essential to study its packing structure (number of contact points, their orientation etc.) and its evolution during shear deformation. This research attempted such particle-level observation inside a triaxial specimen using micro X-ray CT system (SP-μCT) at BL20B2.

We developed a micro triaxial apparatus suitable for SP-μCT, which enables us to keep a confining pressure constant and to apply a precise axial strain to a small specimen with 3.4 mm in diameter and 10 mm in height. The material used is Toyoura sand, a standard sand commonly used for geotechnical engineering research, whose grain size ranges from 0.1 to 0.2 mm. Two types of specimen, a loose one and a dense one were tested and the stress-strain curves were obtained (Fig.1). The resulting peak axial stresses for both specimens are rather higher than those with a conventional tri-axial test whose specimen size is over 50 mm in diameter and 100mm in height. It is mainly due to the effect of relatively-thick (0.15mm) membrane wrapping the specimen.

Loading was stopped several times during the test, as it is observed in Fig.1 by the vertical stress drop, to take a series of X-ray images. Fig.2 shows the reconstructed CT images of a central vertical cross section of the dense specimen before and after loading. It can be recognized that the shear deformation is concentrated on the upper part of the specimen, accompanying a considerable dilation (volume increase). The images are clear enough to quantify each grain motion including its rotation. Such information as 3-D microscopic motion of grains in a shear zone, which has never been observed before, is quite useful for the verification of microscopic constitutive model as well as particle-level simulation.