A precise study on undrained shear behavior of hydrate-bearing pressure core from the Eastern Nankai Trough

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In March 2013, the first offshore gas production from methane hydrate using depressurization method has been done at the Eastern Nankai Trough in Japan [1]. Dissociation of methane hydrate in pore space of the sediments which had supported soil skeleton may lead instability of the reservoir and the borehole. Comprehensive study on geotechnical and geomechanical properties of the sediments, particularly strength and compressibility, is crucial for stability analysis and prediction of ground deformation. Therefore, before this gas production tests, pressure core sampling and analyses had been performed for evaluating several properties of the reservoir including hydrate-bearing sediments [2]. Pressure core is natural sample which is recovered from water depths of thounsands of meters in area with overburdens of several hundreds of meters. Pore pressure and temperature are maintained within the hydrate stability condition from seabed to the laboratory. Pressure core technology minimizes hydrate dissociation of the sample. Mechanical properties of hydrate-bearing sediments were investigated by several kinds of test in this project [3]-[5]. In this study, undrained compression test was conducted on hydrate-bearing pressure core clayey silt with S_h = 23% using Transparent Acrylic Cell Triaxial Testing (TACTT) system. Image processing is applied to evaluate validity of the test and quantify the localization of the failure.

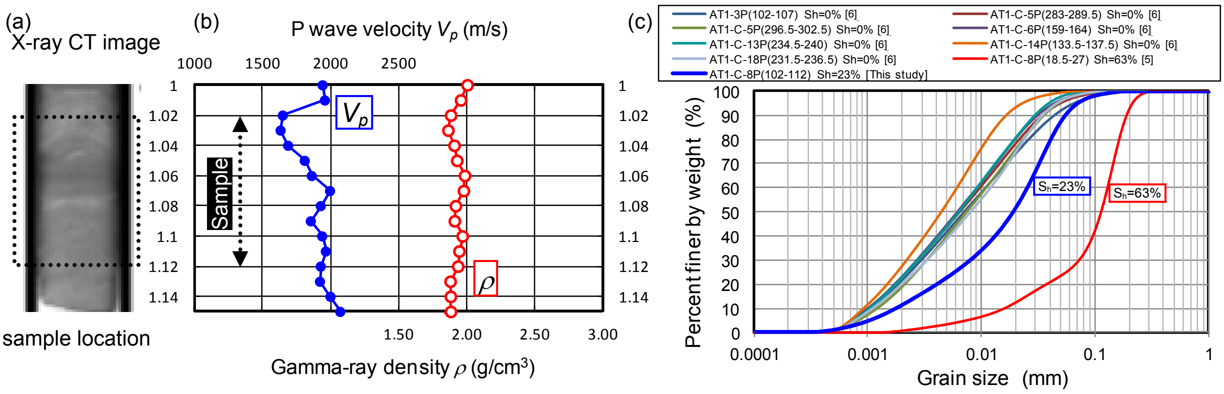

Figure 1. (a) X-ray CT image of pressure core, (b) Physical properties, (c) Grain size distributions

Figure 1 shows (a) X-ray CT image which had taken onboard [2], (b) P wave velocity and gamma ray density of the core [2], and (c) Grain size distributions of sediments recovered from the Eastern Nankai Trough [5], [6]. A part of fewer disturbances was cut as a sample under the pressure. Average P wave velocity and gamma ray density are 1843m/s and 1.934 g/cm^3 respectively. Particle density is 2.71 g/cm^3. This sample classified as clayey silt with mean grain size D_{50} = 20μm. The sediments located intermediate part between sand and mud in the turbidite layer. The sample was set up into the sealing sleeve on TACTT system under 10 MPa of water pressure. After 0.2MPa of confining pressure was applied as initial preconsolidation, single drainage isotropic consolidation was done with 11.5 MPa of cell pressure. Consolidation time was 1200 minutes by 3 t method and the hydraulic conductivity was 2.0 x 10^{-8} cm/s calculated based on one-dimension consolidation theory. Undrained compression shear test was conducted in 0.05%/min axial strain rate.Figure 2 (a) shows stress strain curves of this study's sample and the results of previous research [6]. Stiffness is almost same as previous study. However, strength is lower than previous work even with S_h = 23%. Digital photos were taken during the compression and three dimensional coordination of target maker pasted on shealing sleeve were measured. Figure 2(b) shows local axial strain contours at each strain level. Node of each mesh was the centroids of each target maker's area. Orientation of core was upside down due to core retrieve procedure. Shear banding was observed after 5% of axial strain. This shear banding may generate localized excess pore pressure which are not measured and lead low shear strength. Poisson's ratio based on image analysis was approximately 0.5. It was increased up to 0.6 after shear band was occurred. Local stiffness of this core for each 5 mm slices are calculated. The results show that the stiffness increases with increasing of P wave velocity. Hydrate saturation might distribute in this sample. This study showed the potential of this testing system and the range of geomechanical properties of hydrate-bearing sediments recovered from the Eastern Nankai Trough. Clayey silt with low hydrate saturation might be fragile layer.

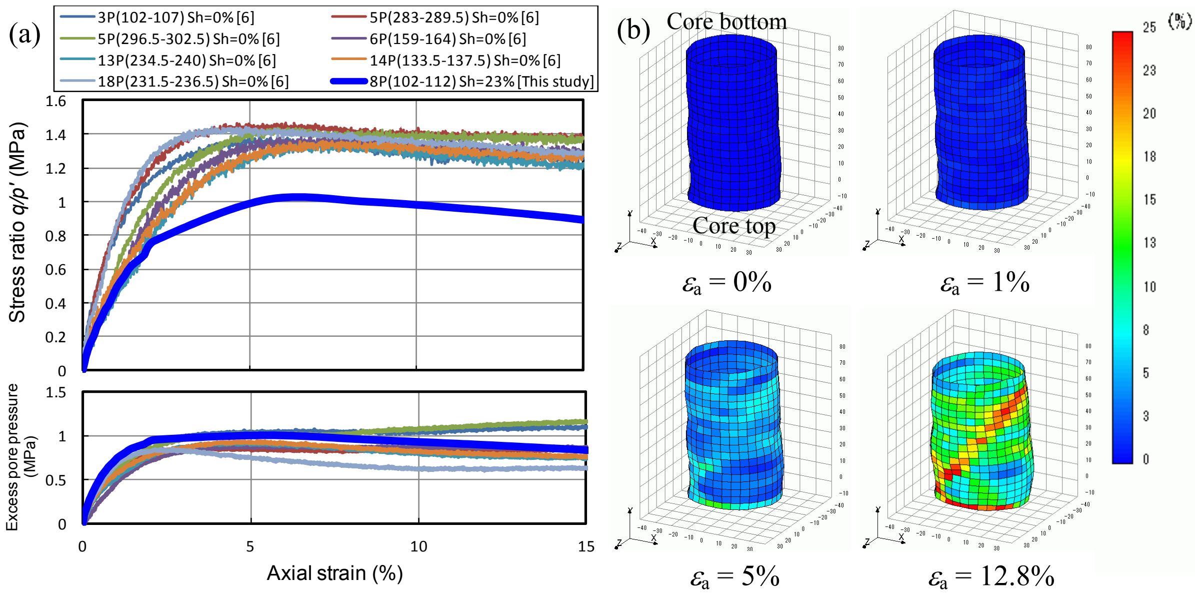

Figure 2. (a) Stress strain curves, (b) Local axial strain contour.

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