

Evaluation of particle morphology of artificial pumice soil subjected to torsional shear

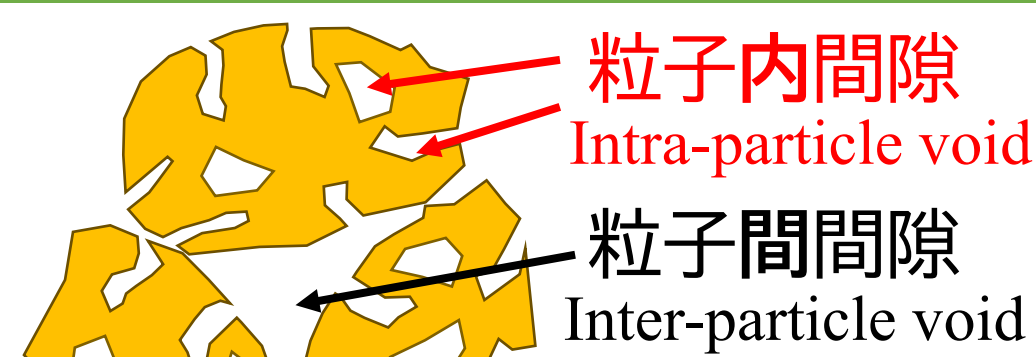
ねじりせん断を受けた人工軽石の粒子内間隙比と粒子形態の評価

A series of torsional shear tests were performed using a porous and crushable artificial pumice soil. X-ray CT images of pumice particles before and after the tests were obtained to quantitatively assess changes in the intra-particle void ratio and particle morphology. It was found that contractancy of pumice specimens was primarily due to the decrease in the inter-particle void ratio, rather than the decrease in the intra-particle void ratio. The pumice particles after tests had transformed into more compact shapes with fewer local irregularities due to particle breakage.

本研究では、破碎性を持つ人工軽石を用いて中空ねじりせん断試験を実施した。試験前後の試料から採取した軽石粒子のX線CT画像を取得して、圧密・せん断を受けた軽石粒子の内間隙比や粒子形態の変化を定量的に評価した。

人工軽石の圧密・せん断に伴う体積収縮(=間隙比の減少)は、粒子内間隙比の減少よりも、破碎により生じた小さな粒子が粒子間隙を埋めることによる粒子間隙比の減少の方が支配的な要因であることがわかった。試験後の粒子は、粒子破碎によって、よりコンパクトで局所的な凹凸が少ない形状に変化していた。

Background



Characteristic of pumice soils :

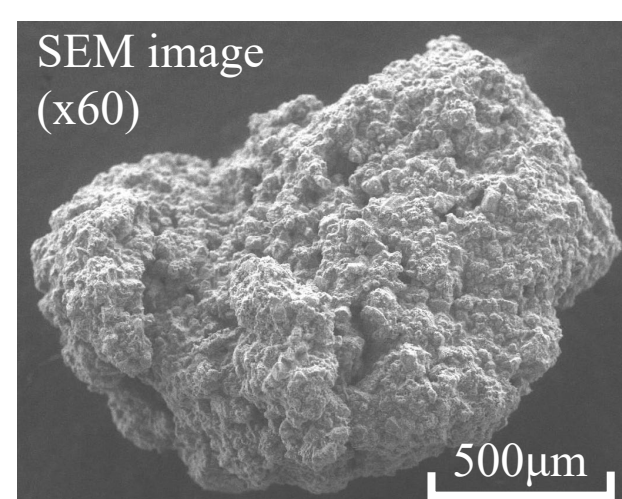
- Existence of intra-particle voids
- High crushability and contractancy

Research Objective:

Quantification of the intra-particle void ratio (e_{intra}) and particle morphology using 3D images of pumice particles.

Material & Test Procedure

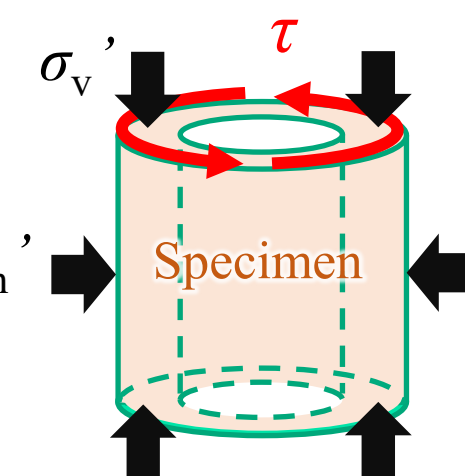
Material: Artificial Pumice soil



- Mixture of DL clay, cement and water
- Porous & Crushable
- High void ratio ($e = 2.28$ at $Dr = 70\%$)

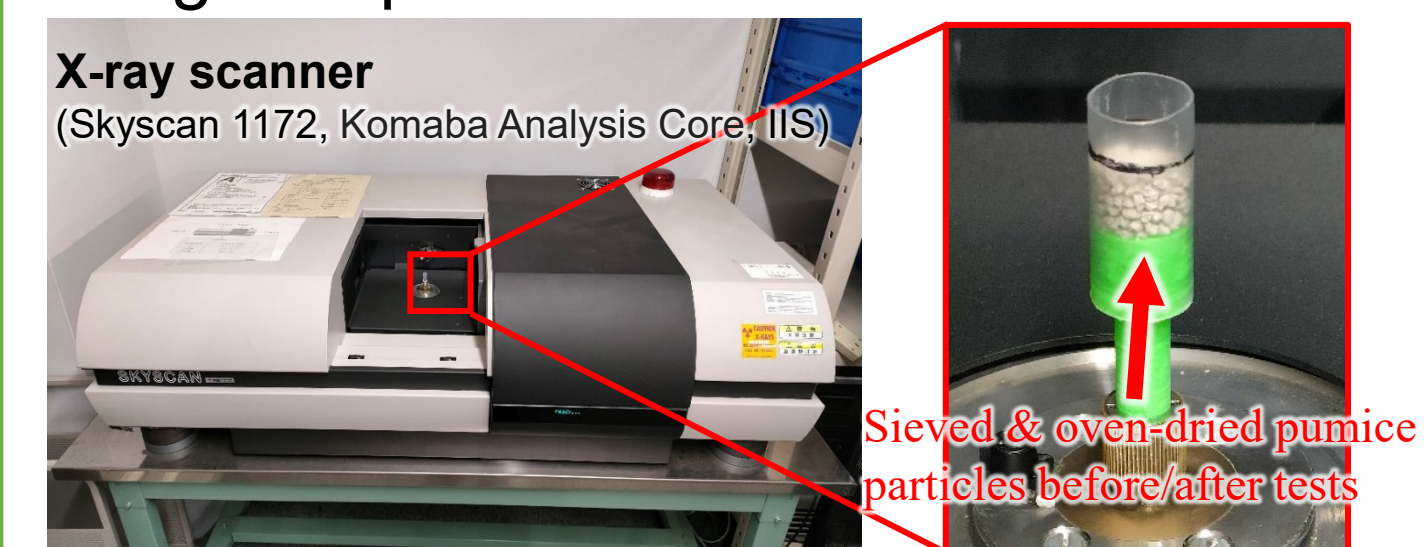
Torsional shear test

- Specimen preparation & saturation
- Isotropic Consolidation (20→500kPa)
- Drained torsional shear under constant p' until shear strain $\gamma = 15$ or 30%
- Sieving



X-ray CT analysis

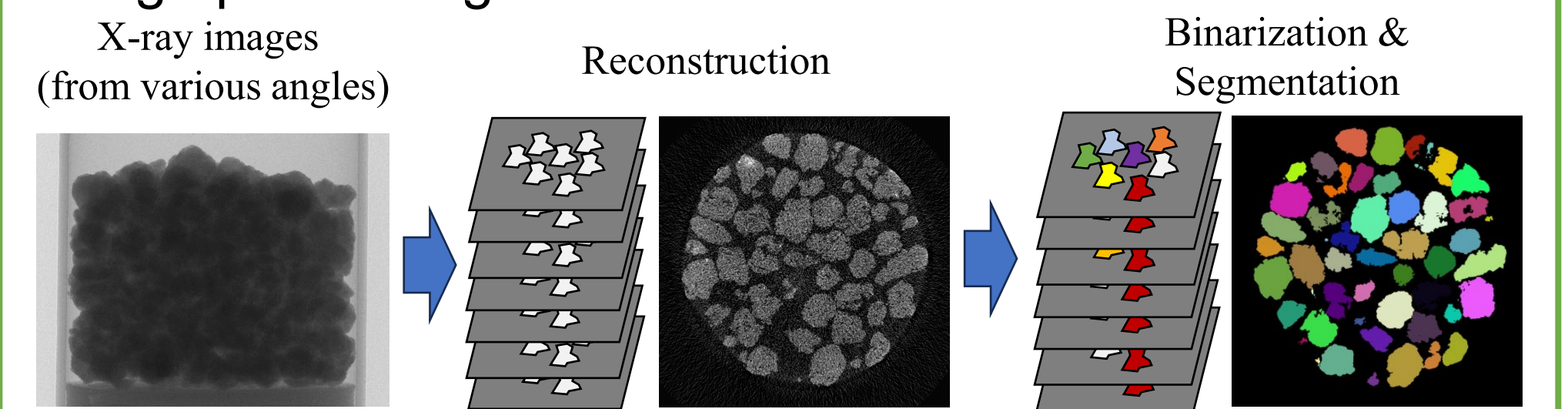
Image acquisition



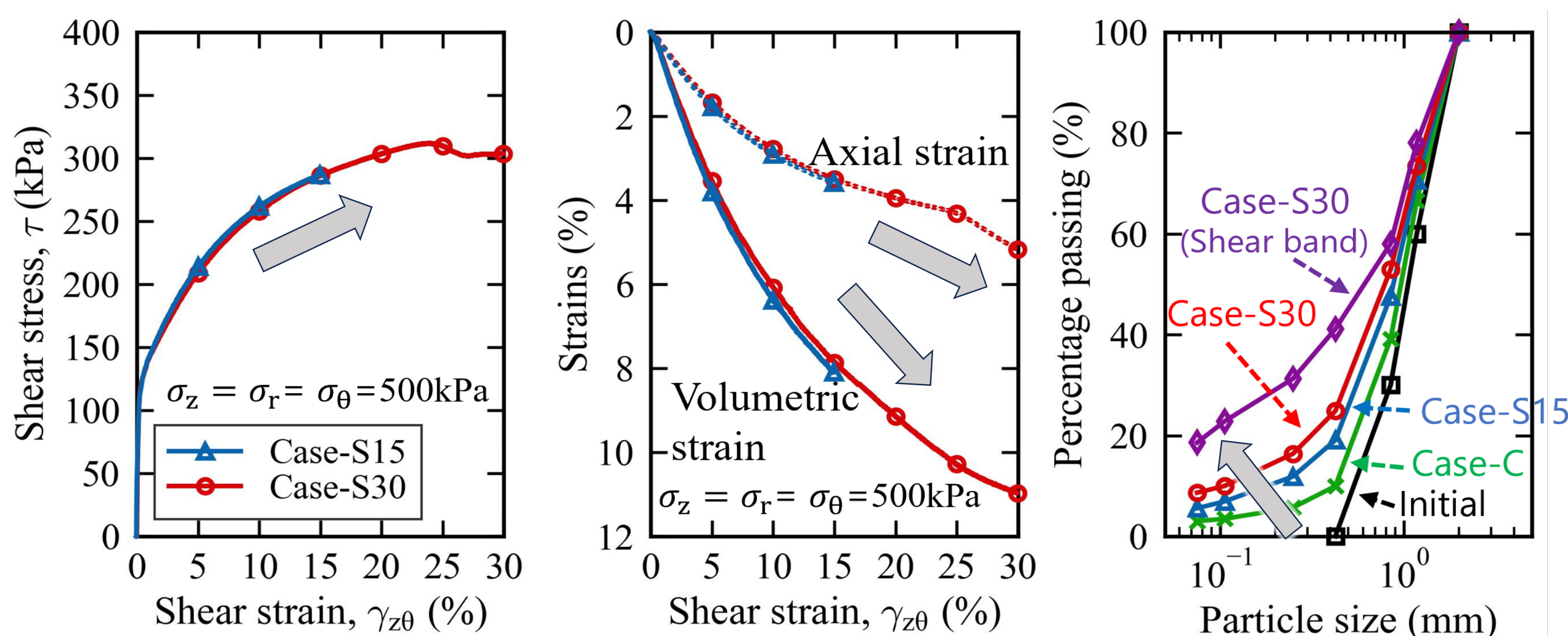
voxel size (μm)	particle size (mm)
5.0	0.106-0.25 0.25-0.425
7.5	0.425-0.85 0.85-1.18
14.8	1.18-2.00

Resolution of 3D images

Image processing

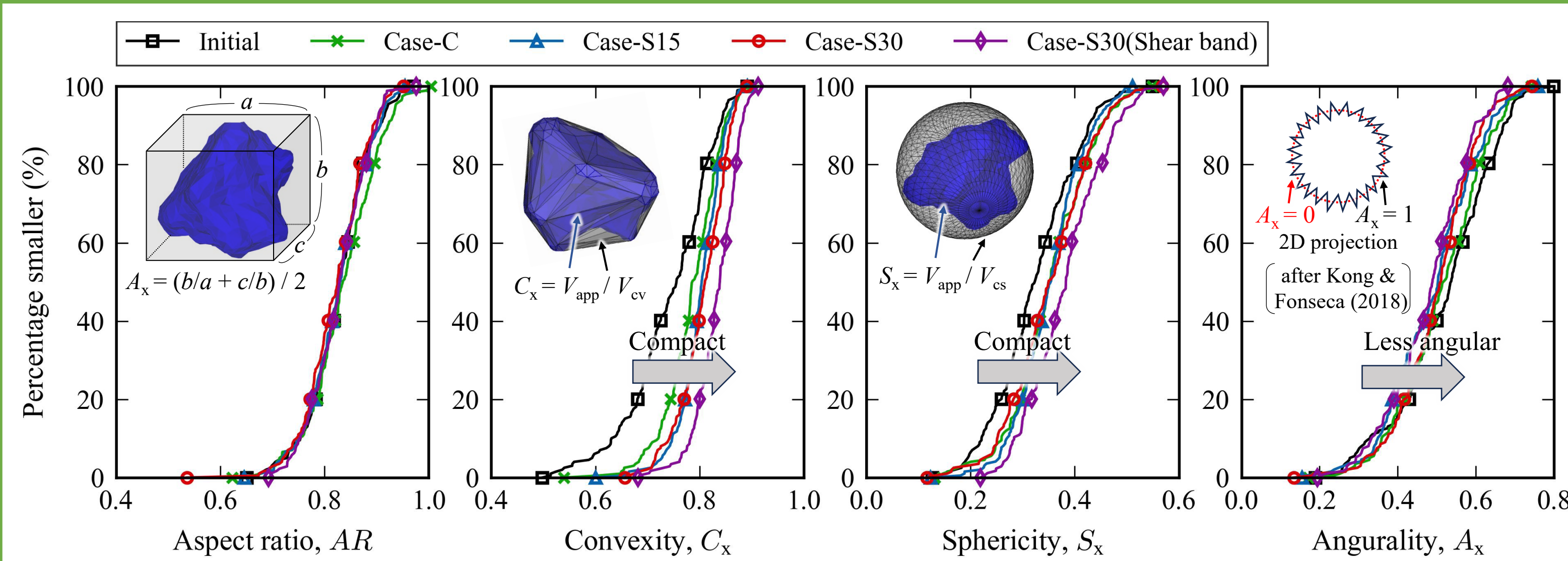


Results of torsional shear



- Shear stress gradually increased, and strain softening was not observed.
- Significant contractancy and particle breakage was observed.

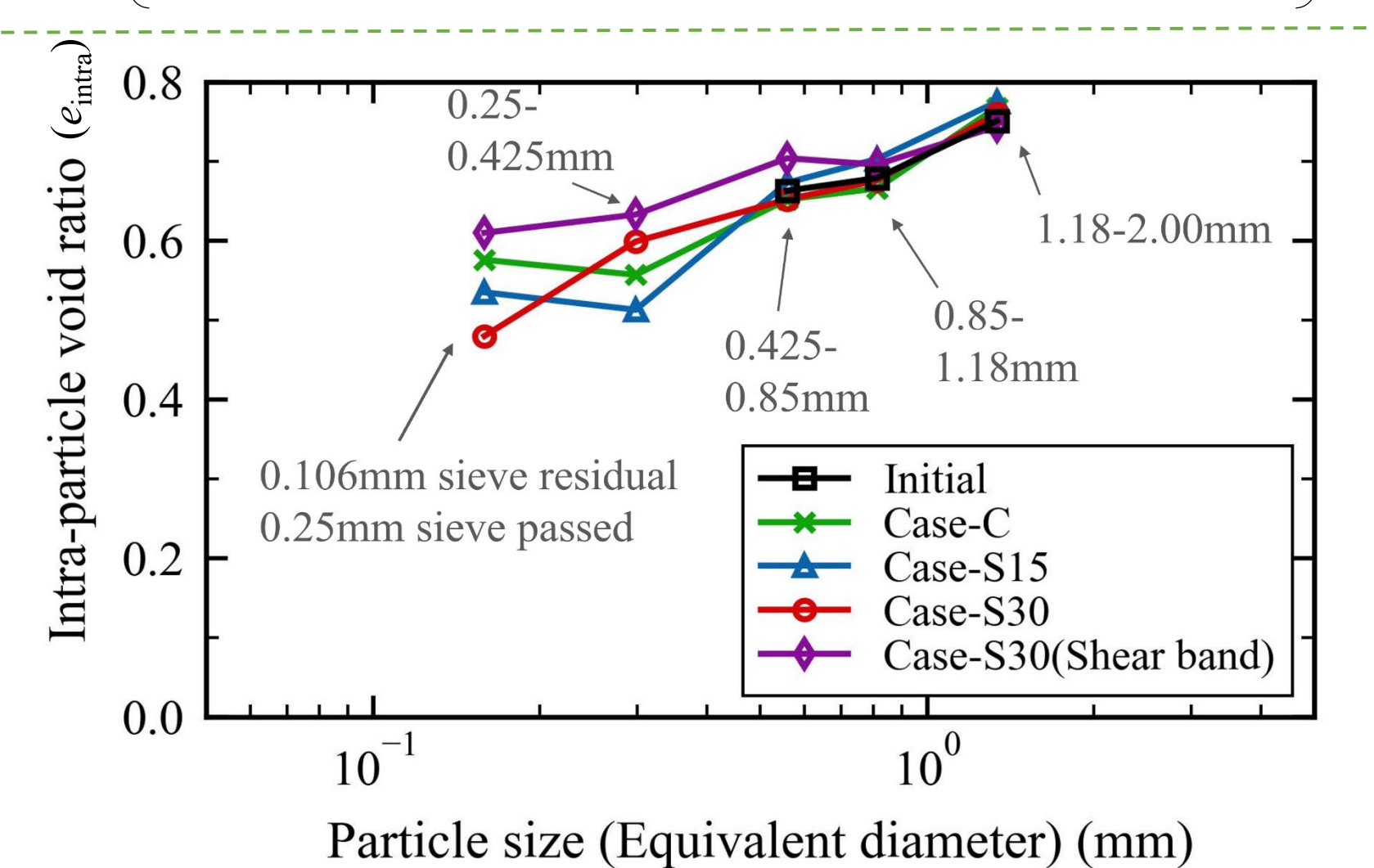
Evolution of particle morphology



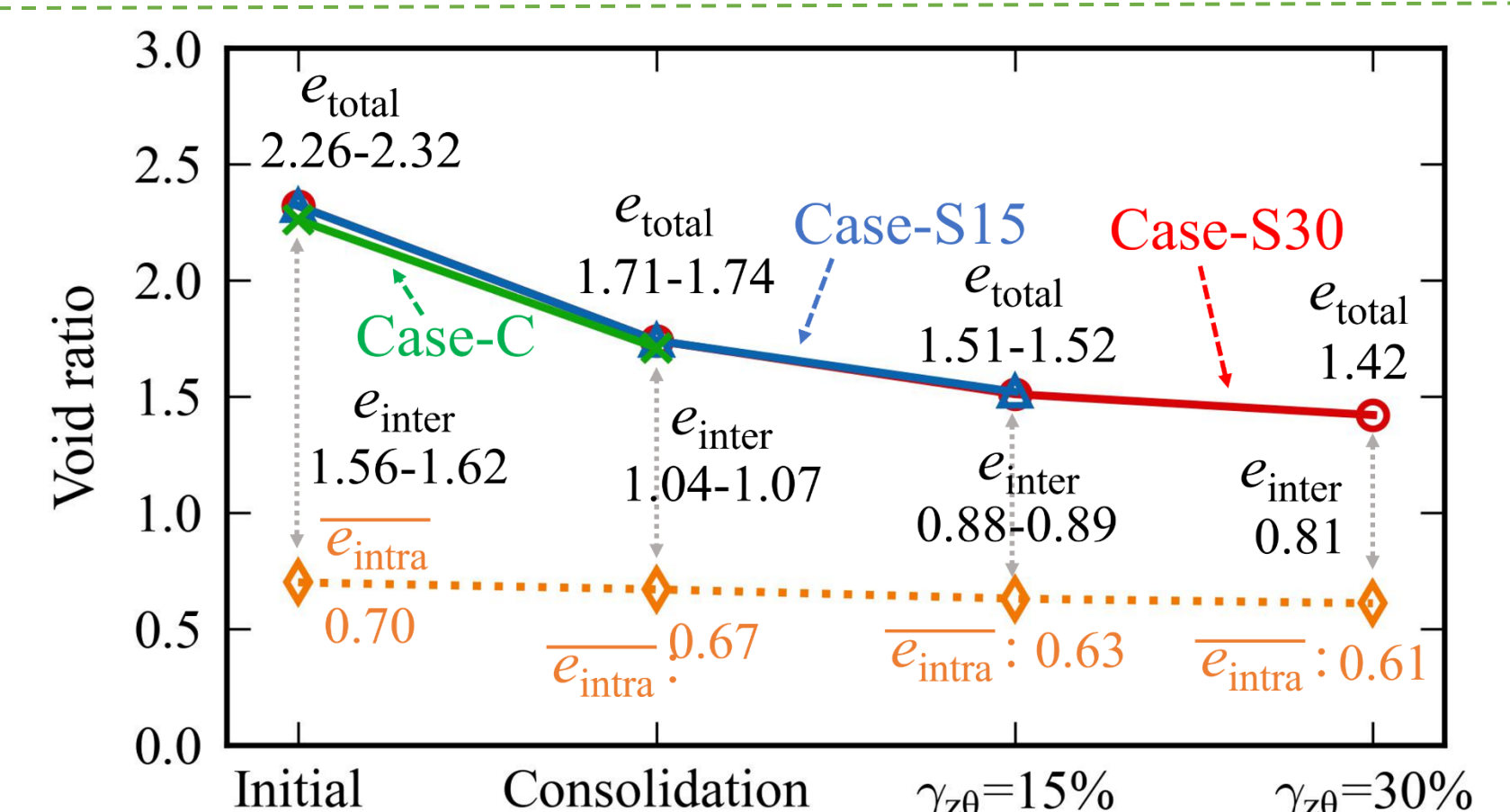
Evolution of void ratios

$$e_{\text{intra}} = (V_{\text{app}} - V_{\text{solid}}) / V_{\text{solid}} = (V_{\text{app}} - M / \rho_s) / (M / \rho_s)$$

V_{app} : Apparent volume of particles M : Dry mass of particles
 V_{solid} : Solid volume of particles ρ_s : Solid density of particles



- Smaller particles showed lower e_{intra} values.
- No significant differences were observed before and after the test when comparing particles of the same size.



- Decrease of $\bar{e}_{\text{intra}}$ was larger than that of inter-particle void ratio (e_{inter}).
- Filling of inter-particle voids by particle fragments generated by particle breakage was the primary factor in the contractancy of the pumice soil.

