EVOLUTION OF PARTICLE MORPHOLOGY OF PUMICE SUBJECTED TO TORSIONAL SHEAR

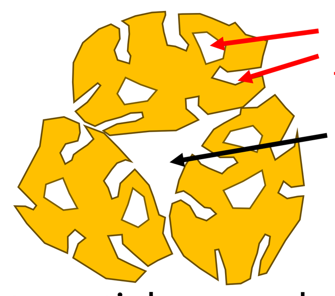
Hiroyuki Hashimoto[1], Masahide Otsubo[2], Reiko Kuwano[3] (Mail: hsmt@iis.u-tokyo.ac.jp)

[1]The University of Tokyo, Department of Civil Engineering, [2]Port and Airport Research Institute, Geotechnical Engineering Department, [3]The University of Tokyo, Institute of Industrial Science

Background

Characteristic of pumice soils :

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



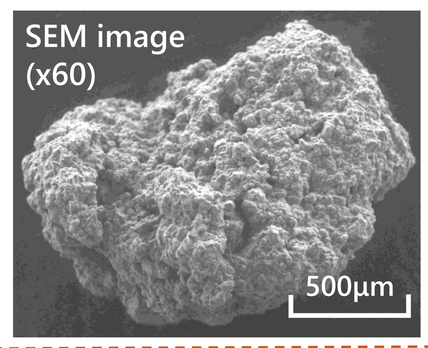
- In normal sand, it has been investigated that particle morphology changes significantly subjected to particle breakage
- But it has not investigated in pumice soils

Research Objective:

Evaluation of particle morphology (shape and intra-particle voids) using 3D images of pumice particles subjected to consolidation and shear

Material & Test Procedure

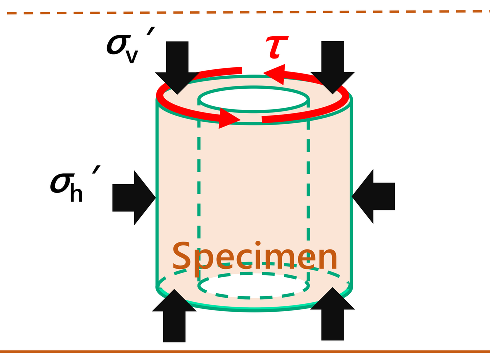
Material: Artificial Pumice soil



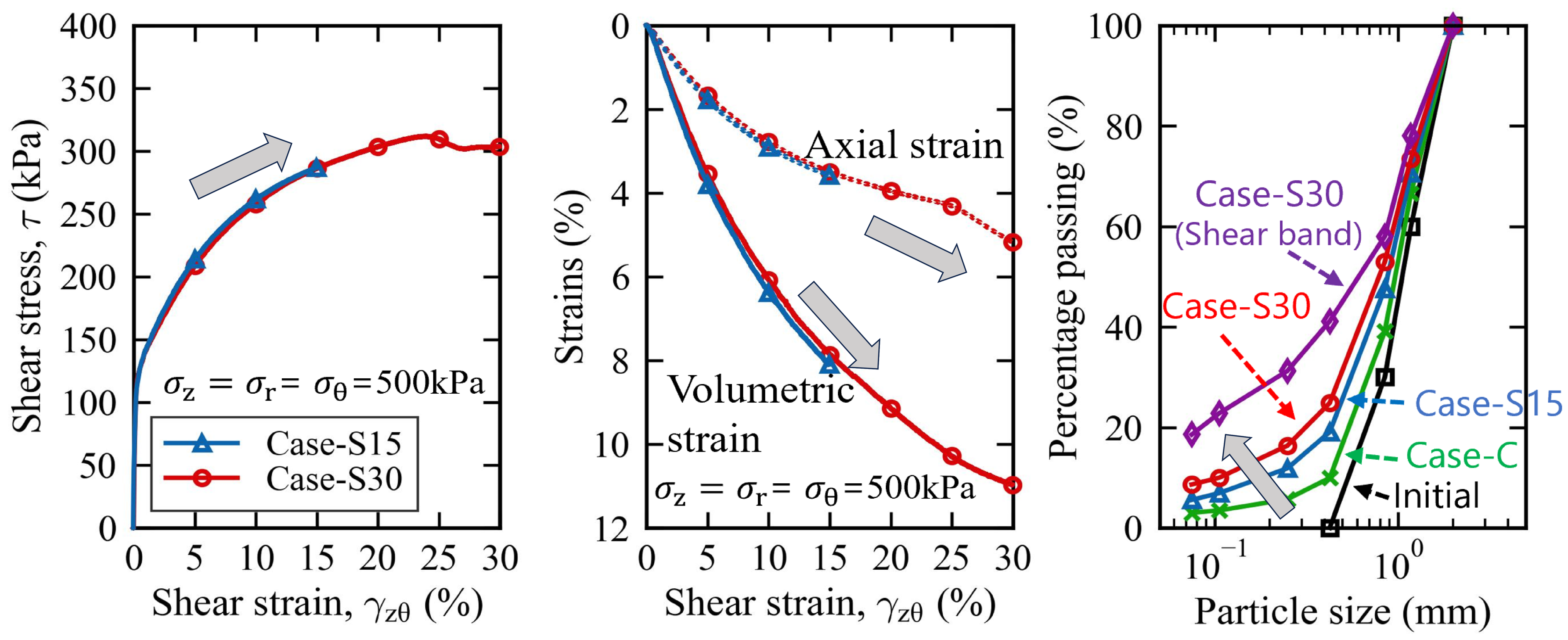
- Mixture of non-plastic silt (DL clay), cement and water
- High reproducibility
- Porous & Crushable
- High void ratio (e = 2.28 at Dr = 70%)

Torsional shear test

1. Specimen preparation & saturation
2. Isotropic Consolidation (20→500kPa)
3. Drained torsional shear (under constant p' until shear strain γ=15 or 30%)
4. Sieving -> X-ray CT analysis



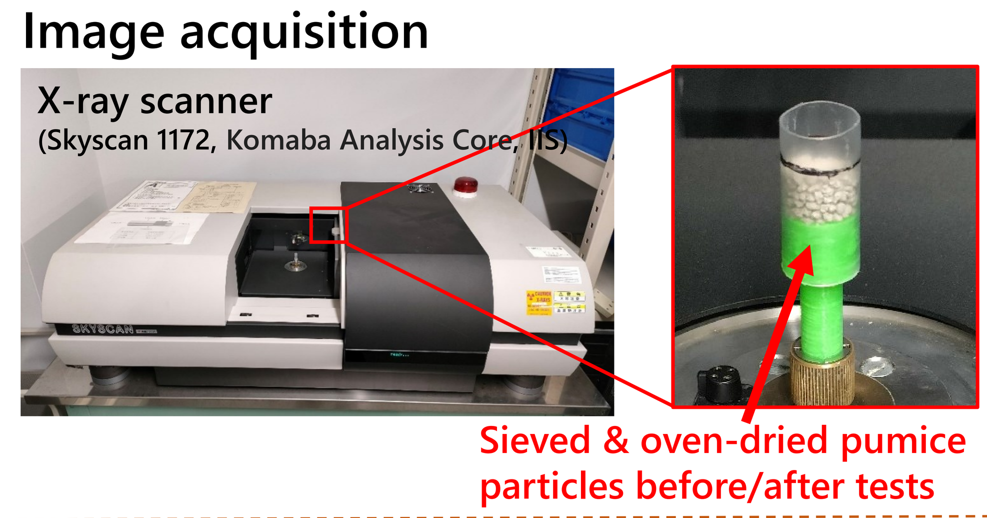
Results of Torsional Shear



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

X-ray CT Analysis

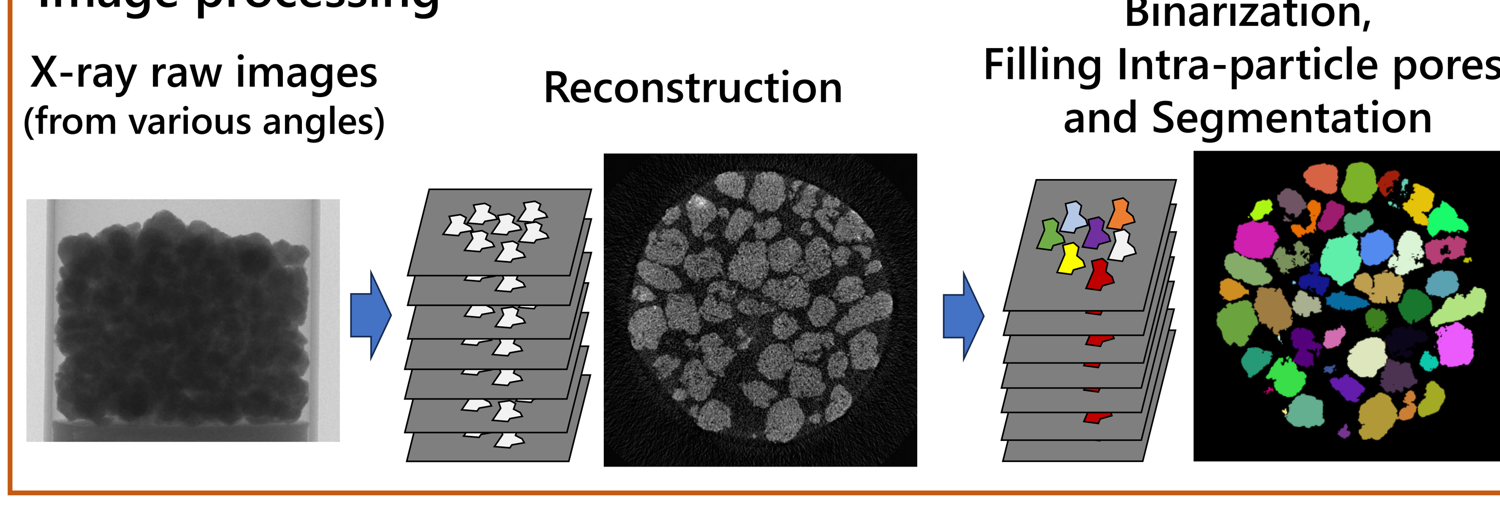
Image acquisition



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

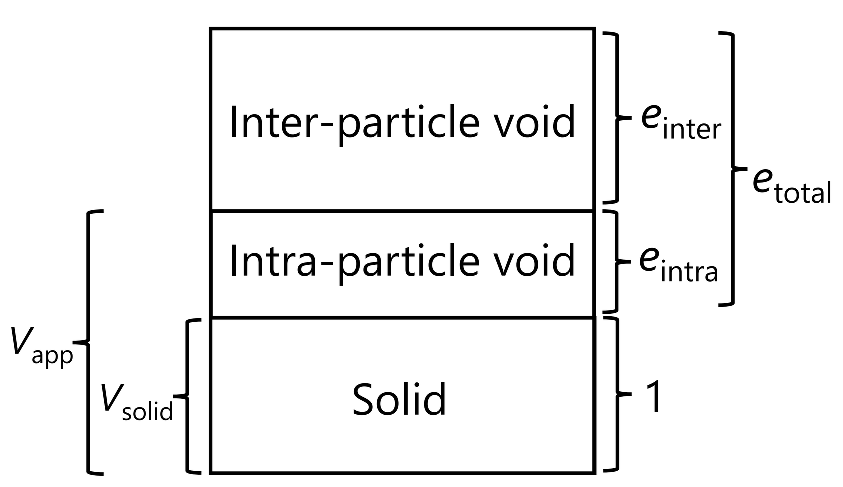


Evolution of void ratios

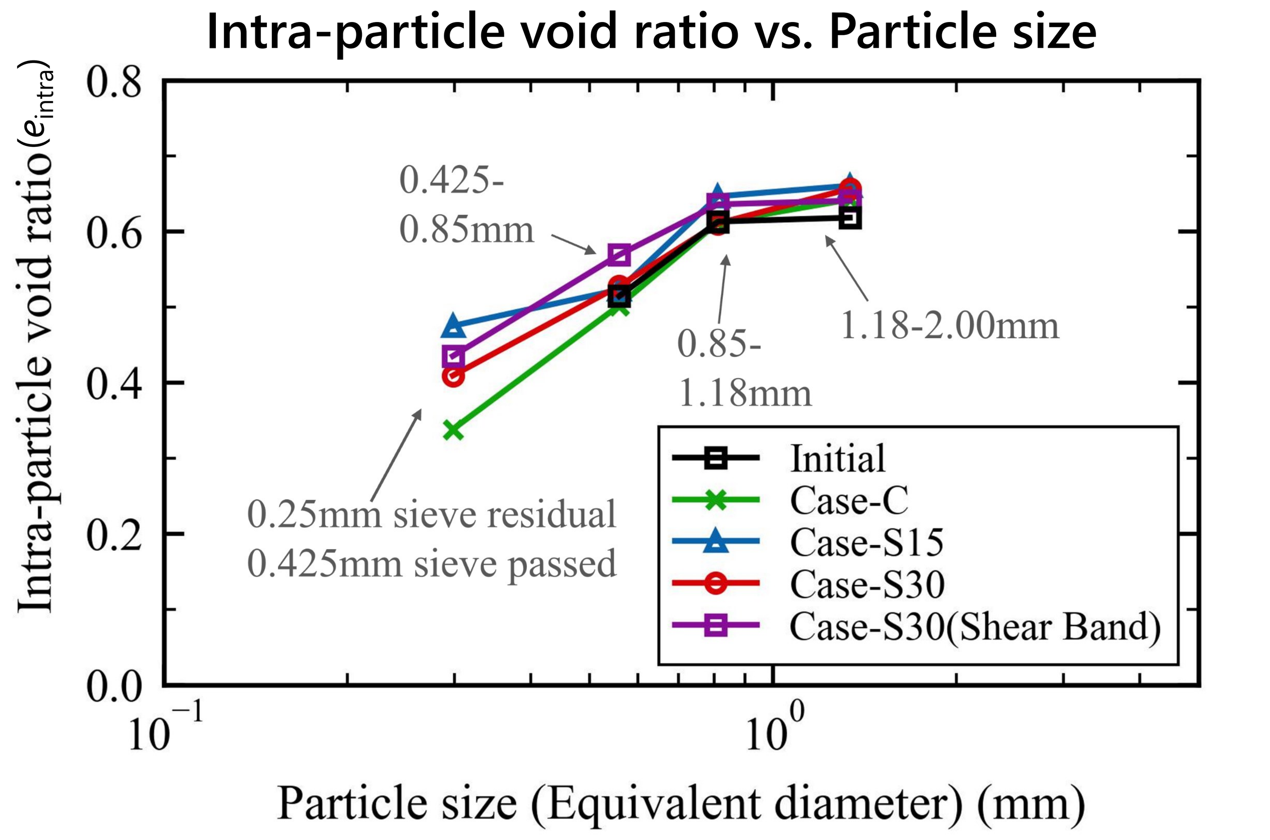
Definition of Intra-particle void ratio

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

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

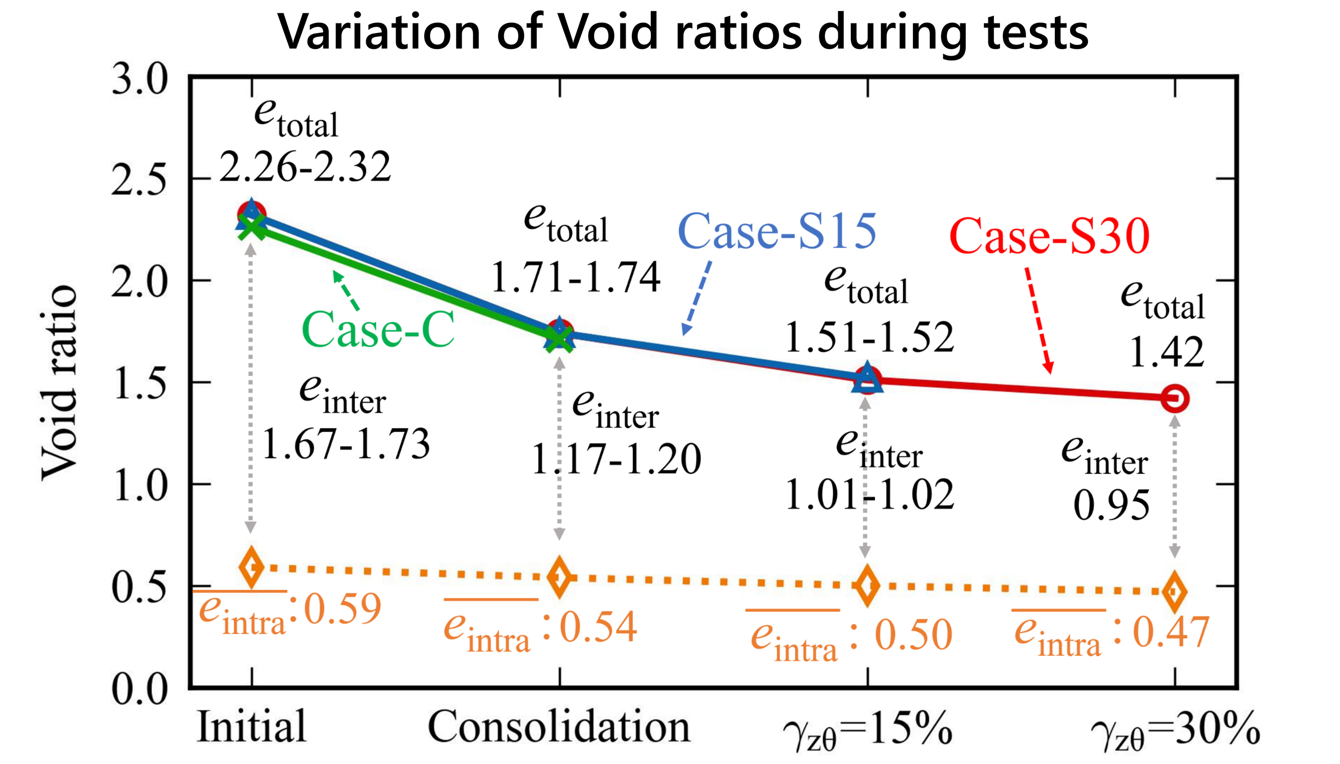


Intra-particle void ratio vs. Particle size



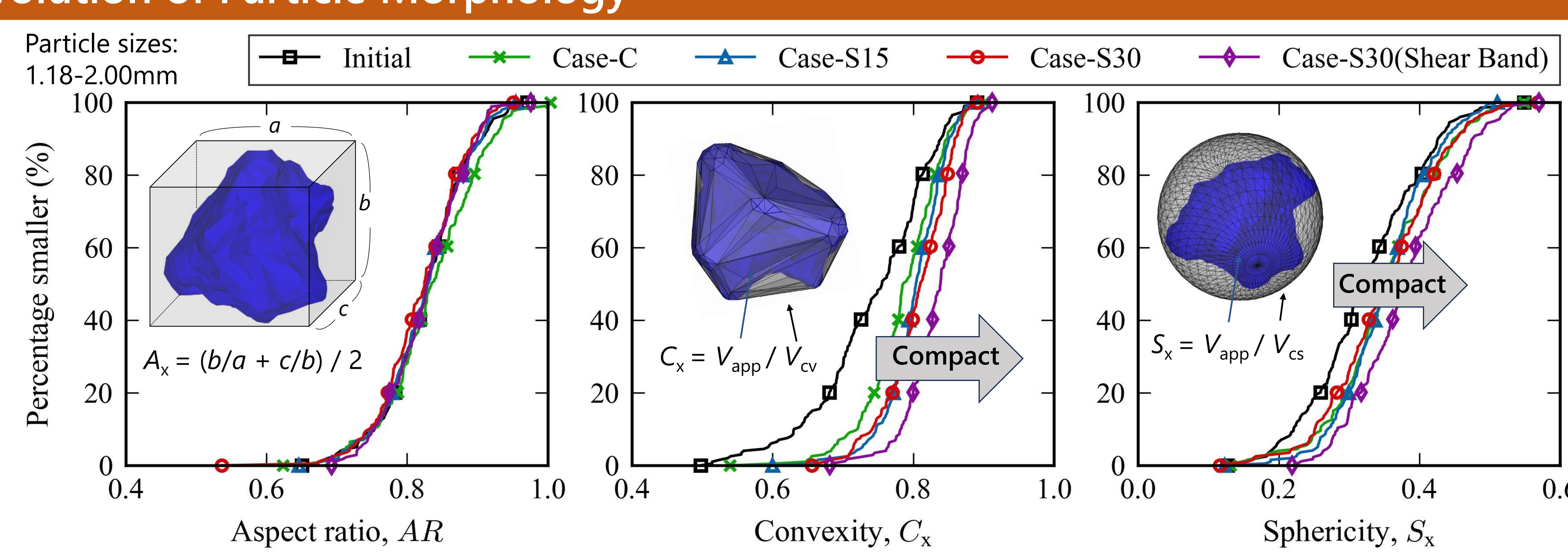
- Smaller particles showed lower e_{intra} values.
- No significant differences were observed before and after the test when comparing particles of the same size.

Variation of Void ratios during tests



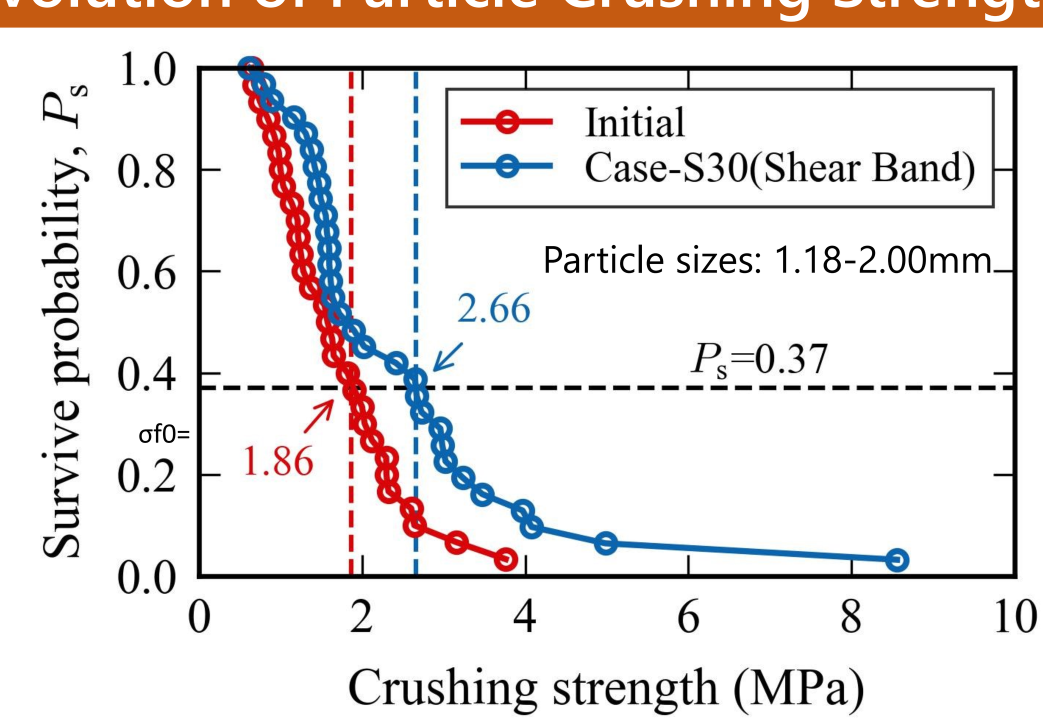
- Decrease of e_{intra} was larger than that of e_{inter}
- Filling of inter-particle voids by particle fragments generated by particle breakage was the major factor in the contractancy of the pumice soil.

Evolution of Particle Morphology



- The pumice particles had transformed into more compact shapes due to particle breakage.

Evolution of Particle Crushing Strength



- Pumice particles after shear showed higher crushing strength.

Conclusion

Evaluation of particle morphology (shape and intra-particle void ratio) of pumice particles subjected to torsional shear using X-ray CT images

- Significant contractancy and particle breakage was observed in drained torsional shear tests.
- Smaller particles showed lower e_{intra} values, but no significant differences were observed before and after the test when comparing particles of the same size.
- Decrease of e_{intra} was much larger than that of e_{inter}
- The pumice particles had transformed into more compact shape and showed higher crushing strength.

Future Plan: Study with natural pumice soils