Dependence of cracks in fractured powder materials on particle size distribution: similarity to glass transition

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Morphological change of fractured fragile material which is composed of a lot of adhesive powder particles is investigated by 2-dimensional discrete element method (DEM). We call simply such materials powder materials.

We examine how the fracture aspect of the powder material is changed if the standard deviation of the particle size distribution, σ , or the strength of the adhesive force between particles, χ , increases. We find that when σ =0.0 the powder material is fractured with large straight cracks. As σ increases under fixing χ , the cracks are subdivided and the shapes of the cracks become complicated. Finally, the powder material is broken up into many small pieces. Correspondingly, the fractal dimension D_f increases from approximately 1.2 to 2.0 as σ increases (Fig.1). This means that the aspect of fracture is changed from cracking to crumbling. Interestingly, the increase in D_f is not monotonous, but seems to start from a particular point of σ . By analyzing the fractional free volume S_f in the powder material, we also find that S_f is almost constant until a point of σ , σ_g, and increases linearly with σ for $\sigma > \sigma_g$ (Fig.2). This behavior is very similar with that in the glassy materials, i.e. S_f maintains a constant value if the temperature T is lower than the glass temperature T_g and is proportional to T if $T>T_g$.

We suggest that the morphological change from cracking to crumbling is similar to the glass transition.

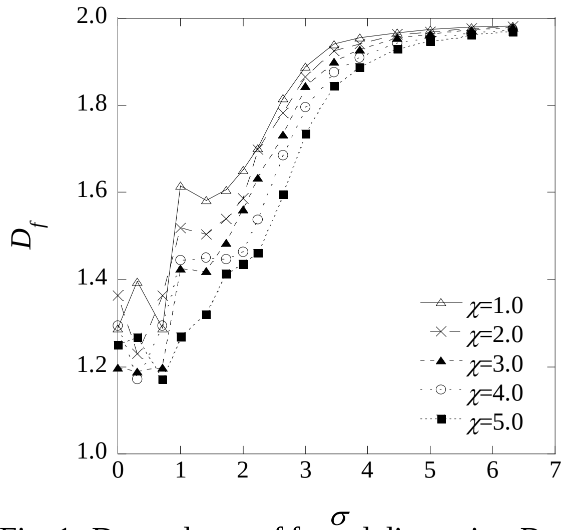

Fig. 1 Dependence of fractal dimension D_f of cracks on particle size distribution σ .

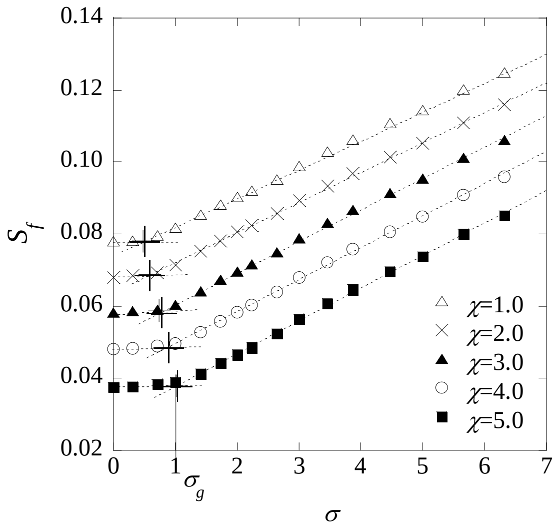

Fig. 2 Plots of fractional free volume S_f v.s. standard distribution σ .

(1) K. Tsurusaki et. al., J. Soc. Powder Technol. Jpn. **44** (2007) 212 [in Japanese].
(2) K. Tsurusaki, T. Matsui, R. Shirasaki, Report of KITC No. 14 (2008) 14. [in Japanese].