Experimental Study on the Tensile Strength of Two-Component Dust Beds

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Knowledge of the tensile strength of dust aggregates or regolith piles is significant for understanding the early stages of planet formation in the solar system and the stability of planetary bodies that may be disrupted by collisions with other bodies or by their spin motion. Experimental studies on tensile strength have been conducted using samples composed of various single-component materials, but few have focused on mixtures.

In this study, tensile strength measurements using the Brazilian disk test were performed on mixtures of silica and graphite. Spherical silica particles with a volume-based median diameter of 1.2 µm and irregular graphite particles with a median diameter of 4.4 µm were used. Mixtures with silica weight fractions ranging between 0% and 100% were poured into a cylindrical container with a diameter of 1 cm and compressed at about 1.6 MPa using a pressing machine, resulting in volume filling factors between 0.37 and 0.60. The tensile strength σ at a volume filling factor Φ was normalized to Φ=0.5 using the empirical equation (Afrassiabian et al., 2016; Rumpf, 1970). The normalized tensile strength values ranged from approximately 3 kPa (100% silica) to 110 kPa (100% graphite), decreasing with increasing silica content, but not linearly. Assuming surface energies of 25 mJ/m^2 for silica (Kendall et al., 1987) and 96 mJ/m^2 for graphite (Fowkes, 1971), and applying Rumpf's equation for spherical particles, the estimated tensile strength for both materials would be about 15 kPa, which is 5 and 0.14 times greater than the measured results for silica and graphite, respectively. Possible causes of this discrepancy include particle shape, surface conditions (such as adsorbed water and surface roughness), and particle size distribution. The tensile strength was expressed as an exponential function of the silica content. In contrast, when the results of experiments using mixtures of two components among ice, silica, and fly ash (Haack et al., 2020) were normalized by the filling factor, they could not be represented by a single exponential function and showed different trends depending on the material combinations.