A NEW ELASTOPLASTIC TANGENTIAL FORCE-DISPLACEMENT MODEL FOR CONTACTING PARTICLES IN GRANULAR FLOW SIMULATIONS

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To estimate the rate of attrition of materials due to breakage under collision in granular flows, it is important to employ contact models that provide accurate prediction of not just the force level, but also the rate of collision among the flowing granular particles. In the present work, we present a new elastoplastic tangential force-displacement (TFD) model for contacting spheres; this model is coherent with the elastoplastic normal force-displacement (NFD) model presented in our previous work [1], [2]. The proposed elastoplastic TFD model is accurate, and is validated against nonlinear finite element analyses involving plastic flows under both loading and unloading conditions. The novelty of this TFD model lies in (1) the additive decomposition of the elasto-plastic contact area radius into an elastic part and a plastic part, (2) the correction of the particles' radii at the contact point, and (3) the correction of the particles' elastic moduli. The correction of the particles' radii represents a permanent indentation after impact; the correction of the elastic moduli represents a softening of the material due to plastic flow. The construction of both the present elastoplastic TFD model and its coherent companion elastoplastic NFD model, parallels the formalism of the continuum theory of elastoplasticity. Both proposed NFD and TFD models form a coherent set of FD models not available hitherto for granular flow simulations, and are consistent with the Hertz, Cattaneo, Mindlin, Deresiewicz contact mechanics theory. Together, these FD models allow for efficient simulations of granular flows (or granular gases) involving a large number of particles.

References

[1] L. Vu-Quoc, X. Zhang, and L. Lesburg. A normal force-displacement model for contacting spheres accounting for plastic deformation: Force-driven formulation. *ASME Journal of Applied Mechanics*, 67(2):363{371, Jun 2000.

[2] L. Vu-Quoc and X. Zhang. An elasto-plastic contact force-displacement model in the normal direction: Displacement-driven version. *Proceedings of the Royal Society of London, Series A*, 455(1991):4013{4044, Nov 1999.