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Y.T. Feng, T. Zhao, J. Kato, W. Zhou

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Towards Stochastic Discrete Element Modelling of Spherical Particles with Surface Roughness: A Normal Interaction Law

Y. T. Feng[1,2]*, T. Zhao[1], J. Kato[1], and W. Zhou[2]
[1]Zienkiewicz Centre for Computational Engineering, Swansea University, UK
[2]State Key Laboratory of Water Resources and Hydropower Engineering Science
Wuhan University, Wuhan, China 430072

Abstract

The current work is the first attempt towards establishing a stochastic discrete element modelling framework by developing a normal contact interaction law based on the classic Greenwood and Williamson (GW) model for spheres with rough surfaces. Two non-dimensional forms of the model that have a substantial impact on the computational efficiency are discussed and the theoretical relationship between the GW model and the Hertzian model for smooth spheres is formally established. Due to the inter-dependence between the contact pressure and deformation distributions in the model, a Newton-Raphson based iterative solution procedure is proposed to effectively and accurately obtain the contact force in terms of the overlap and two surface roughness parameters. The related key components of the procedure are addressed in detail. The numerical results obtained are first validated and then curve-fitted to derive an empirical formula as a new normal interaction law for spheres with surface roughness. The explicit nature of the new interaction law makes it readily be incorporated into the current discrete element modelling framework. A simple example is presented to illustrate the effect of surface roughness on the packing behaviour of a particle assembly.

KEYWORDS: Stochastic discrete element modelling, Greenwood and Williamson model, Surface roughness; Normal contact law

1 Introduction

The discrete element method (DEM) [1] has emerged over the last two decades as a powerful computational technique to simulate and predicte the behavior of systems of a particulate or discrete nature in many scientific and engineering applications [5]. The basic procedure of the DEM involves: 1) to represent particles as rigid geometric entities in various packing configurations; 2) to conduct contact detection to evaluate interaction forces between particles based on some appropriate physically based interaction laws; and 3) to assemble all the forces acting on each particle and to numerically solve the resulting dynamic equations of particles in the system to update their accelerations, velocities and positions at discrete time instants. This computational framework of the DEM is essentially *deterministic* in that all the input parameters and loading conditions must be known *in prior*, and the system behaviour is determined in a definitive manner. However, a significant degree of randomness

*Corresponding author; e-mail: y.feng@swansea.ac.uk