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On the diametric compression strength test of brittle spherical particles

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Abstract

Diametric compression testing can be used to measure the hoop strength of spherical particles if one uses platens whose deformation behaviour is tailored in a way that allows the particles to sink sufficiently far into the platens before particle fracture takes place. To obtain the hoop stress of a compressed spherical particle at the moment of failure, and thus interpret the strength tests, an analytical solution derived by Hiramatsu and Oka is generally used. In deriving their analytical equations, Hiramatsu and Oka assumed that the contact stress between the spherical particle and the platens is radial and uniform along two equal diametrically opposed spherical caps.

Here we revisit, by means of the finite element method, the mechanics that underlie the diametrical compression of a linear elastic sphere between two parallel and planar elasto-plastic platens. We show that the Hiramatsu and Oka equations give valid hoop stress values only when the contact area between the compressed sphere and the platens is less than roughly 5% of the equatorial sphere cross-sectional area. At higher contact areas, when the spheres are more deeply embedded in the platen material and the test can be used to measure the particle hoop strength, the Hiramatsu and Oka solution underestimates the hoop stress. By conducting a parametric study, we provide simple expressions that can be used to quickly, yet accurately to within the $\approx 5\%$, compute the hoop stress of compressed spheres in diametric compression tests as a function of the contact area knowing only two parameters, namely the Poisson's ratio of the material making the sphere and the sphere/platen contact friction coefficient.

Keywords: Diametric compression, Spherical particles, FE analysis, Local strength,

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