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Mechanics of Deep Penetration of Soft Solids

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Micromechanical models are developed for the deep penetration of soft solids by a flat-bottomed and a sharp-tipped cylindrical punch such as a hypodermic needle. The soft solid represents mammalian skin and silicone rubbers, and is modelled by a one term Ogden strain energy function. The flat-bottomed punch penetration model assumes that penetration is by the formation of a mode II ring crack that propagates ahead of the penetrator tip. The sharp-tipped punch penetration model assumes that penetration is by the formation of a planar mode I crack which is wedged open by the advancing punch. The steady-state penetration load is obtained by equating the work done in advancing the punch to the sum of the fracture work and the strain energy stored in the solid. The penetration pressure for a flat-bottomed punch is three times that for a sharp-tipped punch, in agreement with experimental observations.

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