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The impact of strain, bedding plane friction and overburden pressure on joint spacing

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In layered sequences, rock joints usually best develop within the more brittle layers and commonly display a regular spacing that scales with layer thickness. A variety of conceptual and mechanical models have been advanced to explain this relationship. A limitation of previous approaches, however, is that fracture initiation and associated bedding-parallel slip are not explicitly simulated; instead, fractures were predefined and interfaces were welded. To surmount this problem, we have modelled the formation and growth of joints in layered sequences by using the two-dimensional Distinct Element Method (DEM) as implemented in the Particle Flow Code (PFC-2D). In PFC-2D, rock is represented by an assemblage of circular particles that are bonded at particle-particle contacts, with failure occurring when either the tensile or shear strength of a bond is exceeded. Model materials with different rheological properties can be generated by calibrating the results of synthetic mechanical test procedures with those of real rocks. Our simple models of jointing comprise a central brittle layer with high Young's modulus, which is embedded in a low Young's modulus matrix. The interfaces between the layers (i.e. bedding planes) are defined by 'smooth joint' contacts, a modelling feature that eliminates interparticle bumpiness and associated interlocking friction. Consequently, this feature allows the user to assign macroscopic properties such as friction along layer interfaces in a controlled manner. Layer parallel extension is applied by assigning a velocity to particles at the lateral boundaries of the model while maintaining a constant vertical confining pressure. Models were extended until joint saturation was reached in the central layer. We thereby explored the impact of strain, bedding plane friction and overburden pressure on joint spacing. The modelling revealed that joint spacing decreases as strain, bedding plane friction and overburden pressure are increased. Contrary to a leading established model the spacing of joints is not a diagnostic feature of joint system saturation.