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Statistics of acoustic emissions and stress drops during granular shearing using a stick-slip fiber bundle mode

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Shearing of dense granular materials appears in many engineering and Earth sciences applications. Under a constant strain rate, the shearing stress at steady state oscillates with slow rises followed by rapid drops that are linked to the build up and failure of force chains. Experiments indicate that these drops display exponential statistics. Measurements of acoustic emissions during shearing indicates that the energy liberated by failure of these force chains has power-law statistics. Representing force chains as fibers, we use a stick-slip fiber bundle model to obtain analytical solutions of the statistical distribution of stress drops and failure energy. In the model, fibers stretch, fail, and regain strength during deformation. Fibers have Weibull-distributed threshold strengths with either quenched and annealed disorder. The shape of the distribution for drops and energy obtained from the model are similar to those measured during shearing experiments. This simple model may be useful to identify failure events linked to force chain failures. Future generalizations of the model that include different types of fiber failure may also allow identification of different types of granular failures that have distinct statistical acoustic emission signatures.