The kinematics and stress in a dense, slowly sheared granular column

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The stress in a column of granular material confined by vertical walls has been of interest since the mid-nineteenth century, when food grains began to be stored in tall silos. It was realized quite early that, unlike in liquid columns, the normal stress at the base of a static granular column does not increase linearly with the head of material. Apart from its importance in the design of silos, the stress in sheared granular columns is also of interest from the standpoint of rheometry – rheological properties of liquids are often measured in a cylindrical Couette device, as they are readily obtained from the stress and strain rate in such viscometric flows. However, very few studies have attempted to determine the rheology of dense granular materials using this device, as the kinematics and stress in granular materials have a more complex relationship. Here, we present measurements of the stress as a function of vertical position in a column of granular material sheared in a cylindrical Couette device. We find that the stress profile differs fundamentally from that of fluids, from the predictions of plasticity theories, and from intuitive expectation. We show that gravity and the confining walls play important roles. We argue that the anomalous stress profile is due to an anisotropic fabric caused by the combined action of gravity and shear.

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