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Building towers, domes, and arches by self-organized solidifying flows

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We demonstrate that a wide variety of delicate solid structures from slender towers to arches, and chiral pagodas can be created by simply pouring a mixture of grains and water on a liquid absorbing substrate [Phys. Rev. Lett. 107, 208304 (2011)]. The same suspension poured on a solid substrate would form a featureless puddle or a pile with an angle of repose. However, an absorbing substrate can quickly drain the liquid from the suspension, rapidly causing the solidification of the fluid into a mechanically stable structure. In a dripping regime, successive drops are observed to jam rapidly upon impact literally stacking on top of each other forming slender granular towers. In a jetting regime and using a moving substrate, the jet is found to bounce on and off the substrate forming regular arches. We will discuss the subtle interplay of the incoming flux of the granular suspension, the drainage efficiency of the substrate, and the mechanical properties of the solid structure. The drainage driven jamming of granular suspensions gives a new route to shape cohesive granular materials and, from a broader perspective, demonstrates the potential a solidifying fluid spreading on a substrate to create new morphologies harder to achieve by other techniques. Applications to surface patterning, rheology of dense suspension and mechanics of wet granular materials will be discussed.