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A flexible, inflatable design has been recently proposed for tall, free-standing structures such as chimneys or solar updraft towers. A theory describing the behavior of such a flexible structure (a stack of toroidal bladders) under wind loading is developed using Lagrangian reduction by symmetry. By varying pressure inside individual bladders, structure deflection can be controlled. A geometric theory of optimal deflection control is also presented. Theoretical and numerical results are compared with experimental data from a prototype. (Received February 15, 2016)