MAR17-2016-005464

Abstract for an Invited Paper
for the MAR17 Meeting of
the American Physical Society

Shaping through buckling in elastic gridshells: from camping tents to architectural roofs[1]

PEDRO REIS, Massachusetts Institute of Technology

Elastic gridshells comprise an initially planar network of elastic rods that is actuated into a 3D shell-like structure by loading its extremities. This shaping results from elastic buckling and the subsequent geometrically nonlinear deformation of the grid structure. Architectural elastic gridshells first appeared in the 1970s. However, to date, only a limited number of examples have been constructed around the world, primarily due to the challenges involved in their structural design. Yet, elastic gridshells are highly appealing: they can cover wide spans with low self-weight, they allow for aesthetically pleasing shapes and their construction is typically simple and rapid. We study the mechanics of elastic gridshells by combining precision model experiments that explore their scale invariance, together with computer simulations that employ the Discrete Elastic Rods method. Excellent agreement is found between the two. Upon validation, the numerics are then used to systematically explore parameter space and identify general design principles for specific target final shapes. Our findings are rationalized using the theory of discrete Chebyshev nets, together with the group theory for crystals. Higher buckling modes occur for some configurations due to geometric incompatibility at the boundary and result in symmetry breaking. Along with the systematic classification of the various possible modes of deformation, we provide a reduced model that rationalizes form-finding in elastic gridshells.

[1]This work was done in collaboration with Changyeob Baek, Khalid Jawed and Andrew Sageman-Furnas. We are grateful to the NSF for funding (CAREER, CMMI-1351449).