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A PHYSICS-BASED REDUCED-ORDER MODEL FOR THE DYNAMIC AND POST-BUCKLING BEHAVIOR OF TENSEGRITY STRUCTURES AND METAMATERIALS

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Abstract. Traditional approaches for modeling the behavior of tensegrity structures have their origin either on form-finding applications or on the desire to capture their quasi-static behavior. As such, they generally assume that (i) bars are perfectly rigid, (ii) cables are linear elastic, and (iii) bars experience pure compression and strings pure tension. In addition, a common design constraint is to assume that the structure would fail whenever any of its bars reaches the corresponding Euler buckling load. In reality, these assumptions tend to break down in the presence of dynamic events. In this work, we develop a physics-based reduced-order model to study aspects related to the dynamic and nonlinear response of tensegrity-based structures. With very few degrees of freedom, our model captures their buckling and post-buckling behavior as well as their dynamic response. We then adopt our model to show how, under dynamic events, buckling of individual members of a tensegrity structure does not necessarily imply structural failure. Finally, we show how through successive reflection operations it is possible to architecture a 3D tensegrity metamaterial, and analyze its response to impacts. Our research suggests that efficient structural design of impact-tolerant tensegrity structures and metamaterials could be achieved by exploiting rather than avoiding the buckling behavior of its compression members.