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Tailored buckling constrained by adjacent members

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Abstract

This paper exploits the accuracy and versatility of additive manufacturing to display interesting buckling behavior in slender elastic columns. A set of parallel columns were printed to relatively high precision, and then subjected to axial loading. The load-deflection behavior is influenced by the post-buckled mutual contact between adjacent columns. Given the capability of incorporating prescribed (but small) initial geometric imperfections using additive manufacturing it is feasible to seed post-bucking behavior, effectively tailoring stiffness.

Keywords: buckling; flexural stiffness; thermoplastic; 3D printing; contact

1 Introduction

One of the major characteristics of axially-loaded structures is that they can be sensitive to relatively small changes in geometry. Accounting for the effect of small geometric imperfections presents analytical challenges, especially for the buckling of shell-like structures. However, the advent of 3D-printing allows a considerable element of control over geometry, and thus promotes the notion of exploiting geometric sensitivity. Furthermore, the versatility of 3D-printing allows the production of essentially identical elements in parallel, including elements that can contact their nearest neighbors.

Classical column buckling has a long history, ranging from the earliest studies of ordinary differential equations [1] and provides an effective illustration of the role of nonlinearities as deflections become large. A good deal of research has focused on arc-length descriptions and the elastica [2, 3] and approximate energy-based methods including finite element analysis [4–8]. More recently, there has also been some notable research on constrained Euler buckling [9–11] in which, for example, an axially-loaded slender column (drill-string) is placed within the confines of a surrounding cylinder [12, 13], or where the extent of post-buckled deflection is limited by contact with a soft [14] or rigid barrier [15, 16]. Much of the recent research has been focused on relatively sophisticated numerical techniques to track post-contact, highly nonlinear behavior