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PII: S0022-5096(15)00035-6
DOI: http://dx.doi.org/10.1016/j.jmps.2015.02.004
Reference: MPS2598

To appear in: *Journal of the Mechanics and Physics of Solids*

Received date: 29 October 2014
Revised date: 2 February 2015
Accepted date: 9 February 2015

Cite this article as: Shmuel Katz and Sefi Givli, The post-buckling behavior of a beam constrained by springy walls, *Journal of the Mechanics and Physics of Solids,* http://dx.doi.org/10.1016/j.jmps.2015.02.004

# The post-buckling behavior of a beam constrained by springy walls

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## Abstract

The post-buckling behavior of a beam subjected to lateral constraints is of practical importance in a variety of applications, such as stent procedures, filopodia growth in living cells, endoscopic examination of internal organs, and deep drilling. Even though in reality the constraining surfaces are often deformable, the literature has focused mainly on rigid and fixed constraints. In this paper, we make a first step to bridge this gap through a theoretical and experimental examination of the post-buckling behavior of a beam constrained by a fixed wall and a springy wall, i.e. one that moves laterally against a spring. The response exhibited by the proposed system is much richer compared to that of the fixed-wall system, and can be tuned by choosing the spring stiffness. Based on small-deformation analysis, we obtained closed-form analytical solutions and quantitative insights. The accuracy of these results was examined by comparison to large-deformation analysis. We concluded that the closed-form solution of the small-deformation analysis provides an excellent approximation, except in the highest attainable mode. There, the system exhibits non-intuitive behavior and non-monotonous force-displacement relations that can only be captured by large-deformation theories. Although closed-form solutions cannot be derived for the large-deformation analysis, we were able to reveal general properties of the solution. In the last part of the paper, we present experimental results that demonstrate various features obtained from the theoretical analysis.

**Keywords:** buckling; large deformations; contact; constrained elastica; guidewire; mathematical modeling; experiment