UNIVERSITÀ DEGLI STUDI DELL'AQUILA

DICEAA
Dipartimento di Ingegneria Civile, Edile-Architettura e Ambientale

AVVISO DI SEMINARIO

Il Prof. Francesco Dal Corso, Associato di Scienza delle Costruzioni presso l'Università di Trento, terrà il 10/07/24 alle ore 10:30, presso l'Aula A-1.2 del Polo di Roio, il seminario dal titolo:

The Elastica sling, the self-tuning dancing rod, and the actuation of soft elastic solids by partial transverse compression from configurational mechanics

Abstract

Initiated by Eshelby [1], configurational mechanics provides a ground-breaking insight into problems where a defect can change its position or increase in size and release energy, which is associated with a force called 'configurational', acting on the defect and causing its movement.

Although configurational forces are historically assumed to differ from Newtonian forces, we show that the former can be interpreted as the latter for a special class of frictionless rigid constraint. More specifically:

- The action of configurational forces on elastic structures is theoretically and experimentally proven in the presence of a specific movable constraint: a frictionless, perfectly smooth, and bilateral sliding sleeve [2]. In particular, the presence of an outward configurational force at the exit of the sliding sleeve is disclosed both via variational calculus and independently through an asymptotic approach;
- The planar equilibrium configurations of this variable-length elastica are found to have shape defined only by the inclination of the two constraints, while their distance is responsible only for scaling the size. The set of sliding sleeves' inclination pairs for which the stability is lost are identified. Such critical conditions allow the indefinite ejection of the flexible rod from the sliding sleeves, thus realizing an elastica sling [3];
- The stabilization of a rod against its fall in the presence of a gravitational field is shown to be possible through a transverse oscillation of a sliding sleeve constraint. The motion results to be periodic or quasi-periodic around a finite average value of the length of the bent rod [4].
- With a strong analogy to fracture mechanics, for a homogeneous elastic solid in frictionless contact against a rigid and rectilinear constraint, ending with a rounded or sharp corner, it is shown that (i.) a path-independent J-integral can be defined, (ii.) which is equal to the energy release rate G associated with an infinitesimal growth in the size of the frictionless constraint, and thus gives the value of the configurational force component

along the sliding direction [5]. It is found that (iii.) such a configurational sliding force is the Newtonian force component exerted by the elastic solid on the constraint at the frictionless contact.

- Assuming the kinematics of an Euler-Bernoulli rod for an elastic body of rectangular shape, the results (i.)-(iii.) lead to a new interpretation from a nonlinear solid mechanics perspective of the configurational forces disclosed for one-dimensional structures of variable length.
- Approximate but closed-form solutions (validated with finite element simulations) are exploited to provide further insight into the effect of configurational forces. In particular, two applications are presented which show that a transverse compression can lead to Eulerian buckling or to longitudinal dynamic motion, both realizing novel examples of soft actuation mechanisms.

The present results are relevant to the design of new soft actuation and energy harvesting mechanisms for advanced technological applications involving extremely deformable structures and soft matter.

Acknowledgements

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References

[1] Eshelby J.D. (1956) The continuum theory of lattice defects. Solid State Physics, 3, 79-144.

[2] Bigoni, D., Dal Corso, F., Bosi, F. and Misseroni, D. (2015). Eshelby-like forces acting on elastic structures: theoretical and experimental proof. Mechanics of Materials, 80, 368-374.

[3] Cazzolli, A., Dal Corso, F. (2024). The elastica sling. European Journal of Mechanics / A Solids, 105: 105273.

[4] Koutsogiannakis, P., Misseroni, D., Bigoni, D., Dal Corso, F. (2023). Stabilization of an elastic rod through an oscillating sliding sleeve. Journal of the Mechanics and Physics of Solids, 181: 105452.

[5] Dal Corso, F., Amato, M., Bigoni, D. (2024). Elastic solids under frictionless rigid contact and configurational force. Journal of the Mechanics and Physics of Solids, 188: 105673.

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Biosketch

After earning a PhD in Materials and Structural Engineering at the University of Trento, Italy, he had a postdoctoral fellowship at the Department of Applied Mathematics and Theoretical Physics, University of Cambridge, UK.

Francesco Dal Corso is currently an Associate Professor of Solid and Structural Mechanics at Department of Civil, Environmental and Mechanical Engineering of the University of Trento, Italy.

His research activity is devoted to the Mechanical behaviour of Solid and Structures. In particular, he dealt with problems related to the localization of deformation, plasticity, large deformations, homogenization, higher-order continua, stress concentrations and singularities, contact mechanics, configurational mechanics, and stability.

He has co-authored more than 50 journal papers. He has co-guest edited a Special Issue of the Journal of the Mechanics and Physics of Solids in 2020 and he is Associate Editor of Frontiers in Mechanical Engineering - Solid and Structural Mechanics section since 2021.