

# Necking of thin-walled cylinders and bifurcations of coated elastic disks

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Necking localization under uniaxial tension is experimentally observed for a ductile thin-walled cylindrical tube, made up of soft polypropylene. Necking nucleates in multiple locations of the tube and spreads throughout it, involving also the occurrence of higher-order modes, evidencing trefoil and fourth-foiled shaped cross sections. No evidence in other ductile materials of such a complicated necking occurrence and growth were found for thin-walled cylinders. With the aim of theoretically modelling this phenomenon, as well as all other possible bifurcations, a two-dimensional formulation is introduced, in which only the mean surface of the tube is considered, paralleling the celebrated Flügge's treatment of cylindrical shells, subject to axial compression. That treatment is extended to include tension and a broad class of nonlinear-hyperelastic constitutive law for the material, which is also assumed to be incompressible [1]. This bifurcation problem is complemented with the akin bifurcation analysis of an elastic disk coated with a Cosserat isoperimetric constraint [2, 3]. The latter is treated as an elastic circular rod, either perfectly or partially bonded and is subjected to three different types of uniformly distributed radial loads (including hydrostatic pressure). As a particular case, a circular elastic rod is analyzed when subject to centrally-directed loads [4]. The presented results find applications in various fields, ranging from aerospace and automotive engineering to the vascular mechanobiology and morphogenesis of plants and fruits.

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## References

1. Springhetti, R., Rossetto, G., Bigoni, D. (2024) Necking of thin-walled cylinders via bifurcation of incompressible nonlinear elastic solids. *Soft Matter*, 20: 5703-5714.
2. Gaibotti, M., Mogilevskaya, S.G., Piccolroaz, A., Bigoni D. (2024). Bifurcations of an elastic disc coated with an elastic inextensible rod. *Proceedings of the Royal Society A*, 480: 20230491.
3. Gaibotti, M., Mogilevskaya, S.G., Piccolroaz, A., Bigoni D. (2024). Effects of prestress in the coating of an elastic disk. *International Journal of Solids and Structures*, 295: 112796.
4. Gaibotti, M., Bigoni D., Cutolo, A., Fraldi, M, Piccolroaz, A., (2024) Effects of different loading on the bifurcation of annular elastic rods: theory vs. experiments. *International Journal of Non-Linear Mechanics*, 165: 104820.