Elastic buckling of perfect cylinders under axial loading

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Cylindrical shells are models used in a wide variety of applications in different fields, ranging from the aerospace, naval and construction industries. This class of structures is characterised by a high ratio between load-bearing capacity and volume. However, the resistance of a cylindrical shell can be compromised by the emergence of buckling phenomena even in the elastic region.

The literature available on the instability of thin-walled cylinders under axial compression is quite extensive, see e.g. [1,2], while the same is not true for the case of tension. Revisiting the work of Bigoni and Gei [3], where buckling under axial compression of a coated cylinder is analysed, we derive the analytical condition of instability for a hollow cylindrical shell under axial tension according to a continuum framework. We show that the buckling condition expressed by means of generalised stresses may be obtained in a more intuitive manner by means of a through-thickness integration of the incremental equilibrium conditions, without any hypothesis on the material behaviour. Assuming a hyperelastic, incompressible and transversely isotropic material about the axis of symmetry, we analyse the buckling load for neoHookean (both in its compressible and incompressible version), Mooney-Rivlin and $J_2$-deformation theory constitutive models. We prove that for the latter case, elastic instability under tensile load is possible.

References

