
Torsional buckling in tape-springs: wavelength considerations

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Abstract

Tape-springs are long, thin, strips with transverse curvature: they are highly deformable and hence widely used in deployable structures applications. When bent in the equal-sense, they buckle torsionally, with a twist angle that oscillates along the length of the spring. This torsional buckling is generally undesirable, as it results in a reduced peak moment capacity. Previous studies have obtained solutions for the twisting curvature as a function of the longitudinal curvature (1,2), however these assume uniform lengthwise deformation, which is contrary to the observed torsional buckling mode: hence these models cannot explain the torsional buckling mode or wavelength.

We offer an explanation for the observed torsional buckling mode by considering two details not captured in earlier studies: the additional strain energy arising from curvature gradients, and the effect of the twist angle on the total applied rotation. The former results in an energetic penalty for short wavelengths, while the latter results in an energetic penalty for long wavelengths: a preferred wavelength hence emerges as a function of the tape-spring geometry. An approximate analytical prediction of the wavelength is found to agree reasonably well with FEA results and some simple experiments using carpenter's tape measures.

- (1) EH Mansfield, Large-deflexion torsion and flexure of initially curved strips, (1973) *Proceedings of the Royal Society of London. Series A, Mathematical and Physical Sciences*
(2) JA Clarkson & KA Seffen, Torsional buckling of a tape-spring: Review and renew, (2024) *International Journal of Solids and Structures*

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