Nonlinear analysis of compliant mechanisms: application to tape springs

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Tape springs

Definition: Thin strip curved along its width commonly used in deployable structures

Assets:
- Passivity and self-actuation
- Elastic deformations
- Self-locking
- Simplicity
- Lightness
- Various combinations
- Compact folded configuration

Theoretical mechanical behaviour:

Bending moment $M$

$M_{max}$

$M_{*}$

$\theta_{max}$

Equal sense bending

Opposite sense bending

Nonlinear finite element models

Quasi-static analyses:
- Shells
- Newmark or generalised-\(\alpha\) method
- Adaptive time stepping procedure
- High numerical damping
- Control on the bending angle

Dynamic analyses:
- Shells
- Generalised-\(\alpha\) method
- Adaptive time stepping procedure
- Low numerical damping
- Importance of the structural damping

Experimental validation and damping estimation

Motion sensors with 4 sensor units
(Codamotion CX1®)

Force plate
(Kistler®)

Deployment tests:

Small amplitude vibration tests:

Motion dominated by the first bending mode:

\(\Rightarrow\) estimation of the structural damping based on the exponential decay of the response

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