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EXPERIMENTAL INVESTIGATIONS TO ENHANCE THE BUCKLING LOAD OF SLENDER BEAMS

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Summary: Due to their capability to withstand relatively large axial loads, slender beam-type structures are a common member in design, e.g. of light-weight structures. Depending on the loads characteristics, constraints and geometry, however, there are different ways such a structure may lose stability, e.g., buckling beyond critical compressive forces. The loss of stability may even cause the structure to collapse in the worst case.

In practice, high efforts are spent to avoid these states of instability and prevent buckling from the beginning. Obvious approaches to enhance the stability of a structure are methods to increase its rigidity passively, e.g., by means of modification of design, material, etc. Nowadays, these methods may not satisfy the challenging design criteria of aerospace, automotive, mechanical, civil and even medical engineering, like volume and weight restrictions or flexibility demands. Instead, it may be advantageous to increase the load capacity by active control strategies.

The present work investigates the stability control of slender beam-type structures under a compressive force. The aim is to enhance the critical load at which buckling occurs by proportional feedback control algorithms. The setup under consideration consists of a cantilever beam loaded by a compressive force. Unlike conventional problems, the compressive force changes its orientation during buckling as it is imposed by tensioning a cable, which passes through a fixed point at the beam's root. For actuation, 12 piezoelectric patches are applied at each side of the beam, as they have proved to be effective, simple to apply and light weighted control devices. The deflection of the beam's tip is measured by a laser displacement sensor.

The main focus of this paper is laid on the experimental realization of stability control. The behaviour of real world structures, e.g., imperfections, sensor noise, discrete measurements, etc. is emphasized. Different control approaches, e.g., discrete shape control or modal control, for a maximum increase of the buckling load are presented. Furthermore, a numerical model is built, calibrated with the experimental settings and detected impacts and numerical and experimental results are compared. Furthermore, an analytical formulation based on the Bernoulli-Euler theory is presented for this non-conservative system.