“有限初始变形”屈曲实验和理论研究

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Abstract：The initial deformation of structures before the onset of buckling is usually very small in conventional concepts, and is always neglected in the conventional buckling theory (CBT) and numerical method (CNM). In this work, we find a class of structures from the emerging field of stretchable electronics, of which the initial deformation becomes large and essential for determining the critical buckling load. The buckling of these structures is referred to as the ‘finite-initial-deformation buckling’ (FID buckling). Although great progress has been made for the buckling theory in the past hundred years, it is still challenging to analyze the FID buckling behaviors. Here, experimental stretch of a series of serpentine interconnects was firstly conducted as a representative example to show the FID buckling behaviors and the inapplicability of the CBT and CNM. The CNM can yield a huge error of 50% on the critical buckling load for the case with thickness-to-width ratio of the cross section h/b=0.6. Most importantly, a systematic theory (FID buckling theory) is developed to analyze the FID buckling behaviors of beams, with the coupling of bending, twist and stretch/compression. As a comparison, various theoretical and numerical methods are applied to three classic problems, including lateral buckling of a three-point-bending beam, lateral buckling of a pure bending beam and Euler buckling. Our FID buckling theory is able to give a good prediction, while the CBT (by Timoshenko et al.) and CNM (by commercial program packages) yield unacceptable results (with 70% error for a three-point-bending beam with h/b=0.8, for example).

Keywords：buckling, three-point bending, critical buckling load, finite deformation mechanics, stretchable electronics

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