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BUCKLING AND POST-BUCKLING ANALYSIS OF SANDWICH BEAM-COLUMNS

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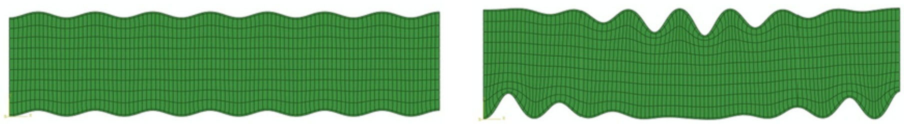
Sandwich structures are increasingly used in many industrial applications, due to the attractive combination of a lightweight and strong mechanical properties. This compromise is realized thanks to the presence of different parts in the composite material, namely the skins and possibly core reinforcements or thin-walled core structure which are both thin/slender and stiff relative to the other parts, namely the homogeneous core material, if any. The buckling phenomenon thus becomes mainly responsible for the final collapse of such sandwiches. One usually distinguishes two types of geometric instabilities, namely the global buckling of the sandwich structure under overall compression and the so-called wrinkling (or local buckling) of the faces which may appear under various loadings. Global buckling can easily be viewed as the classical buckling of the equivalent homogenized structure and only involves the effective properties of the heterogeneous beam or plate in hand. Conversely, the wrinkling analysis requires the use of advanced models.

This study first deals with the linearized buckling/wrinkling response of classical sandwich beam-columns (with homogeneous core materials). Based on a 3D elastic bifurcation analysis, closed-form analytical solutions of the critical loadings and the associated bifurcation modes are derived in a unified way for both mode types (global and local) and with various loading conditions [1]. The present analytical solutions are in much better agreement with reference numerical results, in comparison with previous analytical solutions from the literature, thanks to the particular choice of the kinematic hypotheses in the skins (modeled by Euler-Bernoulli beams) and the core layer (considered as a $2D$ continuous solid).

Then, the advanced post-buckling response of sandwich columns under axial compression is investigated. For this purpose, a specific home-made $2D$ finite element code is used.

It includes (i) branch-switching procedures, that allow one to detect the true bifurcation points (without introducing any imperfection) and bifurcate onto a given branch, and (ii) arc-length methods, which enable one to deal with possible strong non-linearities (non-monotonous curves). The post-critical response of such structures is shown to be always stable after the primary (global or local) bifurcation mode. However, a secondary mode often occurs in practice and leads to an unstable post-buckling behavior, very sensitive to imperfections, as shown in Léotoing *et al.* [2]. The secondary bifurcation mode proves to be local when the primary mode is global and vice versa (see Figure 1 for an example of the successive deformed shapes during the post-buckling stage). Such a non-linear response is particularly observed when the first two (global and local) primary critical loads are close to each other, and it is referred to as the modal interaction phenomenon.



(a) Local primary bifurcation mode (b) Global secondary bifurcation mode

Figure 1: Typical post-critical response of a sandwich column under axial compression.

Finally, for efficiency purposes, an enriched beam finite element model is proposed, as an alternative to our robust but time-consuming 2D model. The main idea is to define the beam kinematics from the exact analytical mode shape of each layer, in order to capture local effects (such as the wrinkling of the faces) during the buckling and post-buckling analyses, following the example of Hu *et al.* [3].

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