Advances in Stability of Composite Airframe Structures Regarding Collapse, Robust Design and Dynamic Loading

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European aircraft industry demands for reduced development and operating costs, by 20% and 50% in the short and long term, respectively. Structural weight reduction by exploitation of structural reserves in composite aerospace structures contributes to this aim, however, it requires accurate and experimentally validated stability analysis of real structures under realistic loading conditions. This paper presents new achievements from the area of computational and experimental stability research of composite aerospace structures which contribute to that field. The first two topics focus on stringer stiffened panels and the last one on imperfection sensitive unstiffened cylinders.

Section 1 presents selected results achieved in the finished EU project COCOMAT, which deals with an accurate and reliable simulation of collapse. The main objective of COCOMAT is a future design scenario which exploits considerable reserves in fibre composite fuselage structures by accurate simulation of collapse. The project results comprise an experimental data base, improved slow and fast computational tools as well as design guidelines.

In today's design process dynamic loading, e.g. due to gusts or landing impact, is assumed to be uncritical, since the dynamic process increases buckling stability. Section 2 shows that rapidly applied loading of stiffened panels can yield critical dynamic behavior in the postbuckling regime. When applying the new design philosophy it has either to be assured that these critical interactions do not occur under the loading velocities to be expected, or they have to be taken into consideration.

Section 3 presents a recently developed approach for unstiffened shells which are usually susceptible to imperfections. This robust design approach is based on a single buckle as the worst imperfection mode leading directly to the load carrying capacity of a cylinder. It also promises to improve the knock-down factors which are according the current guidelines very conservative.

Future work should facilitate full applicability of the analysis methods in preliminary design. For that purpose speed of the collapse analysis of stiffened panels needs to be increased and for collapse simulation degradation must be taken into account. The application field of the robust design method should be widened towards imperfection sensitive stiffened shells (skin-dominant designs).