16th International Conference on Composite Structures
ICCS 16
A. J. M. Ferreira (Editor)

SEMI-ANALYTICAL PROBABILISTIC ANALYSIS OF AXIALLY COMPRESSED STIFFENED COMPOSITE PANELS

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Key words: stiffened panels, probabilistic design, stability.

ABSTRACT

In the present paper, the influence of scattering input parameters on the response of axially compressed stiffened composite panels is presented. In order to estimate the stochastic distributions and the correlations between the first buckling load (or local buckling load), the global buckling load and the collapse load, a semi-analytic probabilistic analysis is performed. With knowledge of the stochastic distributions, probabilistically justified safety factors are derived.

Stiffened fiber composite panels under axial compression show a complex buckling behavior, which, for instance, has been demonstrated by the experimental work of Zimmermann et al. [1]. For stringer dominated designs, the first point of instability is reached when the skin between the stringers starts to buckle. The structural stiffness decreases, but the load still can be increased. With the onset of global buckling, which corresponds to a lateral deflection of the stringers, the stiffness is reduced significantly. Within the European projects POSICOSS and COCOMAT simulation tools and design guidelines have been developed to exploit the load carrying capability of stiffened composite panels, especially beyond the first buckling load (see e.g. [2]). Still, safety factors are required to account for uncertainties or stochastic influences of the important parameters, respectively. The robustness of stiffened panels, taking into account the scattering input parameters, has been determined by Lee et al. [3]. Within the MAAXIMUS project the Institute of Structural Analysis of Leibniz Universität Hannover investigates the scattering of the first buckling load, the global buckling load and the onset of degradation (OOD) due to stochastically scattering parameters. With knowledge about the stochastic distribution of buckling loads, a lower bound of the load carrying capability can be defined by choosing the probability of failure. Hence, probabilistically justified safety factors and the reliability of the structure are obtained.

For the work to be presented, a set of panels tested at DLR in Braunschweig (see [1]) is considered. The geometric imperfections of skin and stringers as well as the wall-thickness, material properties and fiber orientation are regarded as scattering input parameters. The

determination of the buckling loads is done within a geometrically non-linear, numerical simulation using the finite element code ABAQUS. A semi-analytic, probabilistic methodology (as given in [4]) is used to determine the sensitivity and the stochastic distributions of the first buckling load, the global buckling load and the onset of degradation (see Figure 1). Thereby, the probabilistic method is extended in order to be able to investigate the correlation of the buckling loads and the OOD.

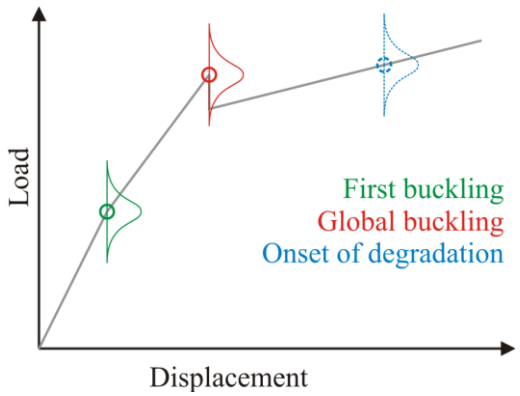

Figure 1: Sketch of the load-displacement curve of a stringer dominated stiffened panel under axial compression

The results indicate that certain parameters have a negligible influence. Furthermore, specific parameters influence the first buckling load, global buckling load and OOD in the same way and hence, lead to a high correlation. For these parameters, only the first buckling load has to be determined for further probabilistic analyses. The main results is that a reliable lower bound of the global buckling load is found, which ensures that the onset of degradation is beyond this design load, as recently proposed in the POSICOSS and COCOMAT design rules.

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