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New achievements in stability of unstiffened CFRP structures

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Aerospace industry demands for significantly reduced development and operating costs. Reduction of structural weight by using composite materials is one avenue to achieve this objective. Thin-walled circular cylindrical CFRP shells subjected to axial compression are a typical structural part in space applications. It is well known that such structures exhibit not only a high load carrying capacity but also prone to buckling which is highly imperfection sensitive. Imperfections are defined as deviations from perfect parameters like shape, thickness, material properties and loading distributions, they can reduce the buckling load drastically compared to a perfect shell. In order to account for these imperfections the theoretical buckling load of a perfect cylinder must be multiplied, and therefore reduced, by a knock-down factor (the ratio of buckling loads of imperfect and perfect cylindrical shell). Thus the closer the knock-down factor reflects the effect of imperfections the better is the prediction of the real buckling load. In the still used NASA SP-8007 design guideline from 1968 a lower bound curve for the knock-down factor is proposed. The factor depends on the slenderness and decreases with increasing slenderness. This factor is rather conservative and the structural behaviour of composite material is not considered adequately. Advanced thin-walled cylindrical shell structures under compression are therefore penalized if the knock-down factor based on this early NASA report must be applied. Hühne developed recently an approach [1] which also promises to improve the knock-down factors. This approach assumes that a larger single buckle is the worst imperfection mode and leads directly to the load carrying capacity N_1 of a cylinder. No further information about the imperfections of the unstiffened structure is needed.

Figure 1 shows experimentally obtained buckling loads [2] dependent of the magnitude of a single perturbation load. Each test result is represented by a dot. It can be seen that if the perturbation load is larger than P_1 the buckling load is almost independent of the magnitude. This structural behaviour promises to calculate the design load N_1 directly using a perturbation load, which is large enough, independent of the kind of the kind of imperfection. However, before setting up a new design approach there is the question for the minimum perturbation load P_1. There are some investigations for the development of an empirical formula for

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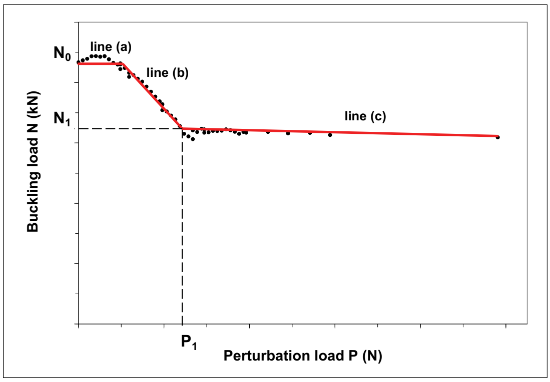

Figure 1: Single-perturbation load approach

metallic structures [3] and also first studies for composite structures [4]. This paper summarizes these achievements which build a basis for a new design scenario.

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