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Post-buckling behavior of a composite panel with spatially varying stochastic material parameters using Koiter's initial post-buckling method

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Abstract

Composite stiffened panels are frequently used in aircraft structures. Such structures are susceptible to buckling, which can occur within the operational range. When designing structures for use within the post-buckling range, i.e. when applying a post-buckled design approach, it is necessary to extract information of the behavior of the structure beyond the first buckling load using post-buckling analyses. Such analyses show buckling modes can interact in the post-buckling region and the behavior of the structure can be sensitive to imperfections [1]. Analyzing the effects of material and geometric imperfections through traditional non-linear post-buckling finite element analysis is very time consuming. The results of the present analysis make use of Koiter's post-buckling analysis and show how variations in material imperfections and modal geometric imperfection shapes affect the buckling load and dominant modes in the post-buckling region.

Koiter's initial post-buckling theory [2] is able to calculate the initial post-buckling behavior of a structure after the critical load has been surpassed. Such information can be useful in determining the dominant buckling modes in the post-buckling regime. Koiter's theory has already been implemented within a finite element framework in previous research [3]–[5]. The research presented here uses such an implementation to analyze the effects of material imperfections varying throughout a composite laminated panel. The imperfections analyzed include varying Young's modulus, fiber orientation and material thickness within a lamina. These material imperfections are combined with the so-called traditional, geometric imperfections, which perturb the ideal geometric shape. The geometric imperfections are included in the way corresponding to Koiter's imperfection sensitivity theory.

The material imperfections are applied to a panel structure using random field methods [6]. This allows the properties to vary stochastically throughout a component according to a specified set of spatial distribution parameters. The stochastically varying material imperfections are applied in a typical laminated panel also containing geometric imperfections. The effects of these combined imperfections on the post-buckling characteristics of the panel are evaluated.

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