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MULTISTABILITY OF PLATES THROUGH VARIABLE STIFFNESS COMPOSITES USING RAYLEIGH RITZ METHOD

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Summary: In the recent past, multistability of composite structure has received a great deal of interest, especially because of its potential to create structures with morphing capabilities. Specifically, when designing morphing structures, the conflicting requirements of load carrying capacity, flexibility and light weight needs to be fulfilled. Bistability was traditionally achieved in unsymmetrical laminates, where the angle of the fiber path was either constant or varied discretely in the plane of laminae.

The concept of Variable Stiffness (VS) Composites was introduced in [1], where the fiber traversed the plane of the laminae with a continuous angle variation. Through VS laminates, a suitable stiffness tailoring is possible which results in easy morphing of the flexible part and load carrying capacity for the stiffer part, enabling to build a single morphing structure that can have a section to carry load and still be light weight. The concept of VS laminates was later used in [2], to analyze the variation of displacement and curvature of a multistable VS laminate during the cool-down process using FEM. However, when employing FEM, finding multiple solutions and accessing their stability can be a difficult task. One plausible strategy to solve such problem is by using semi analytical methods, which rely on classical variational principles.

In the present work, using VS concept [2], a semi-analytical formulation is developed to analyze the multistable solution space of VS plates under thermal loading. The Rayleigh Ritz method is used with appropriate shape functions for the displacement field in order to: firstly identify the multiple potential solutions, and secondly perform the subsequent stability assessment of the obtained solutions. The analysis results provide a relation between the changing orientation of the fibers and the stable shapes obtained for a specific base line configuration. Parametric studies are carried out to determine the plethora of different stable shapes that can be attained using different changing fiber orientations.

References

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