Simultaneous shape and stacking sequence optimization of free-form FRP shells

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Abstract

The desired efficiency of FRP composite free-form shells can be obtained by two ways: shape optimization and stacking sequences optimization[1, 2]. A simultaneous shape and stacking sequence optimization algorithm is developed for free-form FRP (Fiber Reinforced Polymer) laminated shells with the objective to maximize their natural fundamental frequency. The geometrical shape of shells is represented by NURBS (Non-Uniform Rational B-Spline). Natural fundamental frequency is solved by FEM(Finite Element Method). MIGA (Multi-Island Genetic Algorithm) is employed to solve the optimization problem in which coordinates of control points and fiber orientation of each layer are simultaneously proposed as optimization variables. Through several numerical examples, the performance of the proposed approach is demonstrated in comparison to the so-called two-phase optimization method; the effect of boundary conditions and the setup of control points on optimal results is studied.

The main conclusions are as follows: (i) through the simultaneous optimization, the objective value (fundamental frequency) is increased significantly. For the same shell, the relative increase value of objective value is related to the boundary condition; (ii) by comparison, it is clarified that the two-phased optimization is actually seizing local sub-optimal results due the ignorance of coupled effect of shape and stacking sequence. The accuracy of sub-optimal results strongly depends on the given initial stacking sequence. In contrast, the simultaneous optimization can obtain the global optimal result that consider the coupled effect of shape and stacking sequence; (iii)increasing the number of control points introduces more degrees of freedom in the optimization and would result in more optimal results.

References

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