A Framework for Reliability Based Design Optimization of Curvilinearly Stiffened Panels

This research considers an efficient reliability based design optimization (RBDO) of curvilinearly stiffened panels. A sequential optimization and reliability analysis methodology is developed that utilizes the shape and size variables as design variables; the applied compression and shear in-plane loads, and the Young's modulus, all as random variables. The proposed approach, first, conducts the reliability analysis to find most probable point (MPP) of failure and the probability of satisfying the given constraints. Next, each probability constraint is converted to an equivalent deterministic constraint by using its MPP of previous iteration. By replacing the random variables with their MPPs, the current constraint is shifted to meet the desired reliability level. Then the deterministic shape and size optimization is performed to optimize the mass of structures while satisfying the equivalent constraints on buckling, stress, and crippling.

Since the changes in size and shape variables during the optimization process result in different kinds of changes to the structure's performance, the single step shape and size optimization may suffer the lack of convergence and lead to a sub-optimal solution. In addition, due to the large number of design variables, the combined shape and size optimization requires significant computational effort. Therefore, a method for decomposing the shape and size optimization problem is utilized to improve the efficiency and accuracy of developed framework. In the two-step optimization algorithm, the shape and size optimization process is divided into two parts, the first part involves calculation of the best stiffener curve that gives the maximum buckling load subjected to stress and crippling constraints, and the second step consists of a sizing optimization while keeping the stiffener curve unchanged to minimize the mass while satisfying the buckling, stress, and crippling constraints. It is necessary to employ an iterative approach between two steps in order to obtain an accurate optimal result. The updated design variables obtained by deterministic optimization are fed to the reliability analysis to find the probability of safety and update the MPPs. The optimization and reliability analysis cycle are repeated until the objective function is

converged and the probabilistic constraints are satisfied. The sequential RBDO framework employs *EBF3PanelOpt*, a Computational Design Environment for panel with curvilinear stiffeners, to analyze the structures. *EBF3PanelOpt* is developed in a PYTHON programming environment. The finite element commercial software, Msc.PATRAN and Msc.NASTRAN are used to parametrically create and analyze a detailed finite element model of curvilinearly stiffened panels.

The developed sequential RBDO framework also utilizes DAKOTA, Design Analysis Kit for Optimization and Terascale Applications, for reliability analysis and design optimization. The present study includes a number of numerical examples to discuss the optimal design of curvilinearly stiffened panels subjected to probabilistic constraints. In these examples, various combinations of loading conditions such as uniform, linearly varying, and sinusoidally varying in-plane compression and shear loads are taken into account as random variables.