Stiffener Layout Optimization of Thin-Walled Stiffened Plates

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Key Words: Thin-walled stiffened plate, Overall buckling, Ribs layout, Evolutionary structural optimization.

Introduction: Thin-walled structures are widely used in engineering practice. The optimization to enhance the buckling resistance of thin-walled structures remains an active area of research [1]. Reinforced with stiffeners can effectively improve the buckling bearing capacity of thin-walled structures. Ribs layout can be optimized for maximum structural buckling bearing capacity of reinforced structures.

One strategy of ribs layout optimization of thin-walled structures is treating stiffened plate as a discrete plate-beam model which every rib can be designed in optimization. Evolutionary Structural Optimization (ESO) is an effective method [2]. Combination of FEA and computer technology can do the eigenvalue buckling analysis and nonlinear buckling analysis well [3]. This paper presents a strategy of ribs layout optimization of stiffened plate which based on the ideology of ESO method. Simplified “unit influence degree” is used to substitute the sensitivity of the rib and FEA is used to obtain the eigenvalue buckling load of the structure. Stiffened plates under in-plane compressive loads and in-plane shear loads are optimized for obtaining their largest buckling bearing capacities respectively.

Topology optimization design method of stiffened plate: Thin-walled stiffened structure is consisted with two parts which are skin plate and ribs. Ribs are offset on the surface of the plate. Fig. 1(a) shows the initial ribs configuration of stiffened plate. Fig. 1(b), (c) and (d) shows the different boundary conditions and loads respectively.

The object of this research is to obtain the largest buckling bearing capacity structure which is under in-plane loads. Ribs layout optimization belongs to discrete variable topology optimization problems. Based on the initial configuration, each rib is considered as exist or
In Eq.1, ‘0’ expresses removing the rib and ‘1’ denotes retaining.

\[
\begin{array}{l}
\text{find } \{x_i, x_2, \ldots, x_n\} = \{0 \text{ or } 1\} \\
\text{subject to } V = \sum_{i=1}^{n} bhl_i x_i \leq \bar{V}
\end{array}
\]

In Eq.1, \(x_i\) is the existential state of the \(i\)th rib; \(P_{cr}\) represents the eigenvalue buckling bearing capacity of stiffened plate; \(b, h\) and \(l\) are single width, height and length of rib, respectively; \(V\) denotes ribs total volume of ribs and \(\bar{V}\) denotes given limitation volume of ribs. ESO evolutionary strategy based on the sensitivity thinks that optimized structure can be obtained by gradually deleting units which have smallest acuity.

Our research focuses on the buckling bearing capacity of the structure. Approximate sensitivity is used instead of buckling sensitivity which can be obtained by FEM. When deleted rib volume reaches the set requirements, the cycle should be ended. Otherwise, update the structure and continue the cycle process.

**Ribs layout optimization for maximum buckling bearing capacity of stiffened plate:** Ribs layout optimization results of structures are solved. Process of gradual optimization of the structure can be observed from the results and some typical rib distributions of maximum buckling bearing capacity of the structure are found out. The ribs layout optimization results of the structure with approximate 20% rib fractions are shown as Fig.2 (a)-(d), respectively.

![Fig.2 Ribs layout optimization results of the structure with approximate 20% rib fractions, (a):under in-plane loads as Fig. 1(b), (b):under in-plane loads as Fig. 1(c) and \(P_{cr1}:P_{cr2}=1:1\), (c):under in-plane loads as Fig. 1(c) and \(P_{cr1}:P_{cr2}=2:1\), (d):under in-plane loads as Fig. 1(d)](image)

**Acknowledgment:** The authors gratefully acknowledge the financial support by the National Science Foundation of China (Grant No. 11272020).

**REFERENCES**

