PAPER REF: 4622

STIFFENER LAYOUT OPTIMIZATION OF THE OVERALL BUCKLING OF THIN-WALLED STIFFENED PLATE

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ABSTRACT

Based on the finite element analysis technology of thin-walled plate and Evolutionary Structural Optimization method ideology, an optimization strategy which can be easily carried out is proposed and a ribs layout optimization model is built. By structural buckling analysis and Evolutionary Structural Optimization algorithm, the compute of "influence degree" of structural unit and the process of topology optimum work are realized and the paper provides a convenient way to solve the topology optimum problem using Evolutionary Structural Optimization method. In the ribs layout study, stiffened plate in plane loads is optimized for obtaining its largest buckling bearing capacity. Then ribs layout optimum solutions of stiffened plate under a variety of load are got. The effectiveness of the optimum method is verified by the sample application; meanwhile some new examples are optimized that provides reference results of ribs layout for engineering stiffened plates.

Keywords: thin-walled stiffened plate, buckling, ribs layout, evolutionary structural optimization.

INTRODUCTION

Thin-walled structures are widely used in the aerospace, marine, automotive, construction and other industrial sectors. The stability of thin-walled structures have been paid attention by the theoretical researchers and engineering designers. Reinforcing with stiffeners can effectively improve the buckling bearing capacity of thin-walled structures as stiffeners ensure sufficient stability of skin to bear the plane load. Reasonable stiffener layout can not only improve structure's buckling bearing capacity but also save material and reduce weight of structure which has important practical significance.

In general considered, this paper presents a strategy of ribs layout optimization of stiffened plate: based on the ideology of ESO method, finite element analyses is used to obtain the "influence degree" of each rib which is in the discrete plate-beam model of stiffened plate. Then according to the "influence degree" judgment, "Remove" or "Growth operation of ribs is performed to obtain the optimal structure. By comparing the results using this paper's method with previous results of optimal example indicates the feasibility of this optimization strategy. Stiffened plate by in plate load is optimized for obtaining its largest buckling bearing capacity and ribs layout optimum solutions of stiffened plate under a variety of load are got.

Thin-walled stiffened structure is consisted with two parts which are skin plate and ribs. Rib width of the cross-sectional dimension is b, and the height is h, the plate thickness is t. Ribs are offset on the surface of the plate. Finite element analysis model of stiffened plate uses 4-

node finite strain shell element to stimulate skin plate and 3D linear finite strain beam element to stimulate ribs in finite element analysis. Each of ribs is divided into 8 beam elements, and skin plate is free meshed because of the existence of diagonal ribs.

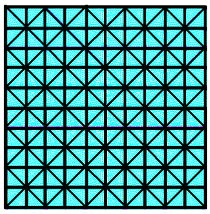


Fig. 1 - Initial ribs layout of stiffened plate

$$\begin{cases} \text{Find} \quad \{x_1, x_2, ..., x_k\} = \{0 \text{ or } 1\} \\ \qquad\quad k = 1, 2, ..., n \\ \text{Max} \quad P_{cr} \\ \text{s.t.} \quad V = \sum_{k=1}^{n} bhl_k x_k \le \overline{V} \end{cases}$$

Mod. 1 Optimization model

RESULTS AND CONCLUSIONS

Using optimization model as Mod. 1, ribs layout questions such as the plate whose four corners simply support bearing the unidirectional buckling loaded and biaxial buckling loaded are optimized. The results of different ribs' volume deletion rate which have significantly distribution law are discussed in the following.

a) Delete 50% ribs b) Delete 60% ribs c) Delete 70% ribs d) Delete 80% ribs

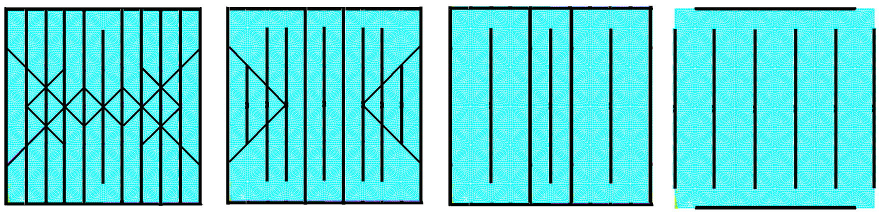
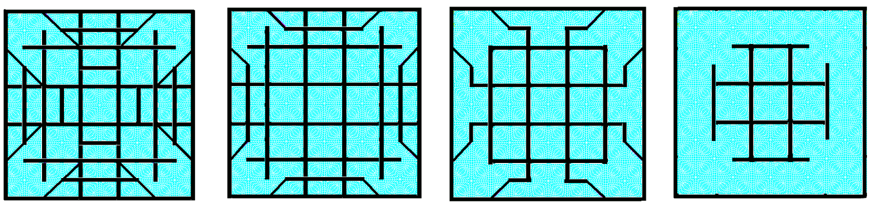
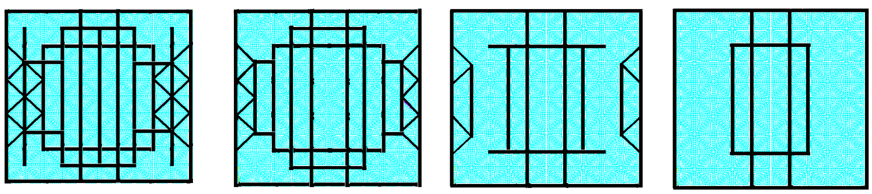


Fig. 2 - Optimum results of unidirectional loaded stiffened plates



(a) Delete 50% ribs (b) Delete 60% ribs (c) Delete 70% ribs (d) Delete 80% ribs

Fig. 3 - Optimum results of 1:1 biaxial loaded stiffened plates



(a) Delete 50% ribs (b) Delete 60% ribs (c) Delete 70% ribs (d) Delete 80% ribs

Fig. 4 - Optimum results of 2:1 biaxial loaded stiffened plates

This paper adopts the idea of ESO method and proposes an optimization strategy which can be easily carried out to solve ribs layout optimization problem of thin-walled stiffened plate. Ribs layout optimizations of maximum stiffness plate and maximum buckling bearing capacity plate are solved successfully.