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Conceptual Design of Box Beam Based on Three-dimensional Topology Optimization

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Abstract

Box beam is widely used in mechanical equipment, such as gantry crane girder, the machine bed and so on. Currently, due to the design mainly relies on traditional design methods include experience design and analogy design, the structure is particularly heavy. In order to reduce weight ,this paper applies the topology optimization to the design of box beam.

Box beam can be simplified as simply supported beam. For simply supported beam, SIMP method is briefly introduced , and the utility of penalization power in it is showed , and the better value of penalization power for the simply supported beam is given. Then, an optimization model for the three-dimensional simply supported beam, in which the compliance is minimized subjected to volume constraint, is established based on SIMP method , and the sensitivity of the objective function is deduced with FEM theory. The Optimality Criteria (OC) method is selected to solve this model. Due to different filter functions have different impact on the topology optimization results , density filter function and gray scale filter function are used to avoid numerical instabilities that will occur in the optimization process. In order to get a new structure of box girder , the girder of bridge crane is selected as the research object . By loading the bridge crane girder in three different positions respectively and using OC criteria to solve each of load conditions , three kinds of structures are obtained . Finally, an optimal topology configuration is obtained by combining the all structures, and its validity is tested by FEM. In this paper , by using three-dimensional model, the internal structure of box girder can be obtained ,which is useful for the layout of the ribs.

By focusing on applying topology optimization method to the box beam concept design stage, the filter function that density filter combined with gray scale filter is better than the one that only using density filter for simply supported beam. The new conceptual structure is light and efficient in material using, which can be divided into two parts: the main structure on the middle and the support structure on left and right sides. There are big trapezoidal holes on the middle part , and the materials upper and lower the support structure are removed . The new conceptual structure meet the stress and displacement requirements by finite element analysis in two load conditions . These results provide a reference for the conceptual design of box girder ,and lay some foundation for the multi-load cases problem. However, the optimization model does not consider the stress, which is the future research direction.