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A discussion about choosing an objective function and constraints in structural topology optimization

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Abstract

As an important branch of structural optimization research, topology optimization has been enriched by lots of solution methods, and remarkable achievements have been obtained because of the numerical modeling methods used in structural topology optimization. Among many studies, a conventional problem of topology optimization, minimum compliance restricted with a given percentage of the total structural volume (structural mass)(MCVC, minimum compliance with a volume constraint), is used widely in both theoretic and application domains. The model construction for the MCVC problems has an obvious advantage while using artificial material method: the objective function and the constraint can be easily formulated explicitly by the artificial relative densities. An important representative work of solving the MCVC problems is the 99-line topology optimization code written in Matlab by Sigmund[1]. It is a convenient and useful learning material of topology optimization for students and engineers to easily modify structural layout for some simple problems.

However, solving the MCVC model has two difficulties. On one hand, a reasonable volume ratio value can hardly be selected in the conceptual design for practical engineering problems if one selects the volume ratio on beforehand. On the other hand, different volume ratios come out different topology configurations, and the final design could be unfeasible in practice since no constraints are imposed on the maximum allowable displacements at some points of the structure. To address these issues, this paper computed tens of examples using 99-line code to show the dependency of the structural optimal topological configurations on the pre-setting volume ratios. We also observed that, when the pre-setting volume ratio is too small, the structure would be broken off or disconnected, and it degenerated into a mechanism. According to above observations, the structural topology optimization model construction was discussed to propose a suggestion about changing the objective function and constraints.

It's found out that taking the practical engineering needs as constraint conditions can solve the above difficulties. Therefore, a topology optimization model is constructed to search for the minimization of structural weight, taking into consideration that the displacement at a point of interest can not exceed a predetermined maximum value (MWDC, minimum weight with a displacement constraint): based on the artificial material method, an explicit constraint function of artificial relative density variables is obtained by using the method of unit virtual load, and the optimization problem is easily solved by using Lagrangian multiplier method. The whole solution framework came out into a corresponding 120-line code written in Matlab[2]. The two optimization models were compared through examples calculation by the corresponding 99-line and 120-line topology optimization codes. Results show that the MWDC model provides a better design. This

proves that the topology optimization model proposed in this paper is feasible in both construction and results.

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Reference:

[1] O. Sigmund (2001) A 99 line topology optimization code written in MATLAB. Struct Multidisc Optim 21:120–127. DOI 10.1007/s001580050176, MATLAB code available online at www.topopt.dtu.dk

[2] MATLAB code available online at www.sites.google/yiguilian/link