# Shape Optimization Method of Shell Structures Concerned with Material and Geometrical Nonlinearity

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## Abstract

In this paper, we present a solution to a reaction force control problem of a shell structure based on the free-form optimization method for shells concerned with material nonlinearity and geometrical nonlinearity. The sum of squared error norms subjected to a specified force is minimized under a volume constraint. The shape optimum design problem is formulated as a distributed-parameter system under the assumptions that a shell is varied in the out-of-plane direction to the surface, whereas the thickness is not varied with respect to the shape change. The shape gradient function and the optimal conditions for this problem are theoretically derived using the material derivative method and the Lagrange multiplier method. The derived shape gradients are applied to the $H^1$ gradient method for shells, which was proposed one of the authors [1], to determine the optimal shape variation. The optimal shape of shell structures can be obtained without the shape parameterization, while maintaining the surface smoothness. The shape gradient function is calculated by a user sub-program which is developed using the result of non-linear FEM analysis based on a commercial solver. Several numerical examples are presented to verify the validity and practical utility of the proposed methodology and the developed system.

## References

[1] M. Shimoda, Free-Form Optimization Method for Shell Structures, Transactions of the JSME, Series A, 79(797), 60-73, 2013. (in Japanese)