

Sensitivity Analysis of Structural Response to External Load Position

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Abstract

In the preliminary design stage of an engineering structure, there often exist some uncertainties associated with the structural design parameters and the loads imposed externally [1]. Over the past decades, structural optimization of a flexural plate with the design dependent or independent loadings has been implemented extensively. Mostly, the application points of the external loads are fixed during the design process [2, 3]. However, it has always been noticed that even a small move or shift of the external load may bring about a significant influence on the performance of a structure and, therefore, change the final optimal design. This paper performs the sensitivity analysis of an external concentrated load such that the variations of the structural static responses can be quickly and precisely evaluated due only to a small motion of the applied load.

This paper is aimed to extend the previous sensitivity study by the present author [4] into the flexural situation of a plate/shell structure. The analysis process is still conducted with use of the finite element (FE) method so that the solution can be applied in conjunction with an existing commercial FE package. First, upon applying the FE equivalence, an external transverse load is transformed into the equivalent nodal forces with use of the adequate interpolation functions. In this case, the shift effect of the external load is represented fairly with the value variation of the associated nodal forces. Next, the derivative of an external load is performed with respect to its position variation. By the aid of differentiation of the shape functions, an explicit formulation of the first-order derivative of the external load is readily obtained. Later, the explicit formulations of the sensitivity derivatives of the nodal displacements and the mean compliance are developed, respectively, to the change of the application point with the load derivative achieved. Finally, a typical example is provided to illustrate the sensitivity calculations of the structural responses. Moreover, it turns out that the response variations can be accurately evaluated with the help of the sensitivities.

References

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