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Configuration Design Optimization of Built-up Structures Using Isogeometric Method

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Abstract

The configuration design optimization of built-up structures is developed using an isogeometric method and configuration design sensitivity analysis. In an isogeometric approach, the NURBS basis function which is used in representing the geometric model in the CAD system is directly used in the response analysis. The NURBS basis functions enable the incorporation of exact geometry into the structural response analysis since the analysis domain is discretized in the early stage of geometry definition. This NURBS basis function is calculated recursively from the given knot vector, and it is very simple to adjust the order of the basis function. Therefore, it is possible to have a more accurate solution than from the polynomial-based FEM, with fewer degrees of freedom. Moreover, refinements are easily implemented and exact geometry is maintained without the subsequent communication with a CAD description. Mesh refinement strategies enable analogues of classical *h*-refinement and *p*-refinement methods, and a new possibility of *k*-refinement.

In this paper, the configuration design sensitivity formulation is derived based on the variational equation for the Mindlin plate element using the material derivative concept and adjoint variable method. The formulation is decomposed into the shape variation and the orientation change of each individual design component of the built-up structure. Various applications of configuration design optimization have been studied so far. However, configuration design optimization for a surface design component has rarely been studied because of the complex parameterization of design domain for a smooth boundary. Unlike the conventional FEM-based shape design optimization, in the isogeometric approach, a separate design parameterization is not necessary, since the boundary of the design domain is already represented by the spline curve from the CAD model. In the case of the configuration design optimization, the shape and orientation variations are considered; the design parameterization is quite difficult and complicated. Therefore, an isogeometric approach is suitable for the configuration design optimization of built-up structures.

Also, the advantages of isogeometric shape design sensitivity and optimization are inherited because configuration design sensitivity analysis includes shape design sensitivity analysis such as accurate shape sensitivity embedding the higher-order geometric information of the curvature and normal vector, and no remodeling process during optimization. The accuracy of the isogeometric sensitivity results is observed by comparing the results of FEM. Because the finite element model consists of a piecewise linear interpolation and lacks the higher-order geometric information of curvature and normal vector, inaccurate sensitivity results can be obtained. Some numerical examples are presented for several built-up engineering structures to show the applicability and superiority of the methodology.

KEY WORDS: Isogeometric analysis, Configuration Design Optimization, Bulit-up Structure, Mindlin Plate, Adjoint Variable Method