A displacement-based element model for solving the edge effect problem of Mindlin-Reissner plate

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Abstract

In Mindlin-Reissner plate problem, the rotations and stress resultants may vary sharply within a narrow area near certain boundaries. This phenomenon is the so-called edge effect or boundary layer effect. Unfortunately, due to the inherent limitations, most existing elements cannot easily capture such steep rotation/ resultant distributions. To solve this problem, scholars have taken different strategies, most of that can be classified into two kinds: (i) employing an extremely fine mesh or an adaptive mesh refinement technique; and (ii) utilizing a very high-order element model. However, both them will result in great computation expense.

In this work, a new displacement-based element model is proposed for analysis of such challenging problem. Firstly, the analytical solutions of two displacement functions *F* and *f* are utilized to assume the displacement filed with the element. Since the displacement, strain and stress/resultant variables derived from displacement functions can *a prior* satisfy all governing equations of Mindlin-Reissner plate, this assumed displacement field is quite reasonable. Secondly, related stress/resultant conditions at certain boundaries are applied as constraints to above assumed displacement field. Therefore, some items of trial functions will be released and the resulting one can exactly satisfy these stress/resultant conditions. Thirdly, the general conforming theory is employed to determine the relations between the assumed displacement field and the element nodal DOFs. The general conforming method is kind of relaxed conforming approach, meaning that the general conforming elements behaves like nonconforming elements on a coarse mesh, and will converge like conforming elements as the mesh refined. Finally, the new elements can be constructed following the principle of minimum potential energy. These new elements can be allocated along the free/SS1 edges to model the boundary layers. Through this way, the edge effect problem can be efficiently solved.

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