A point interpolation method (PIM) based on the couple stress theory

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Abstract:

Many experiments have found that material display strong size effects when the characteristic length at the micron and sub-micron scales. The classical plasticity theories cannot predict the size effects of material behaviour since there is no length scales including in their constitutive relations. The couple stress theory is a kind of strain gradient theories which have been developed to explain size-dependent material behaviour. It is superior to the classic plasticity theory when the characteristic lengths scale is on the order of microns. However, the couple stress theory involves the higher-order stress as the work conjugate of strain gradient, which result in the displacement field requires C^1-continuity when the displacement-based schemes in finite element method (FEM) are used.

This paper develops a new point interpolation method (PIM) based on the couple stress theory using the triangular background cells. We first construct a generalized energy functional for the linear couple stress elasticity, and use a penalty function technique to release the geometric constraints of micro-body rotation, which ensure this procedure does not increase the extra unknown variables. Then we develop a PIM formulation with C^0-continuity satisfying the generalized energy consistency conditions to guarantee the pass of patch test, and further the convergence. Some numerical experiments verify the effectiveness of the proposed scheme.

Keywords: Point interpolation method (PIM); couple stress theory; C^1-continuity; energy consistency; penalty function.