Assessment of nodal integration for meshfree analysis of higher-order gradient crystal plasticity

†Yuichi Tadano[1] and Seiya Hagihara[1]

[1]Department of Mechanical Engineering, Saga University, Japan

*Presenting author: tadano@me.saga-u.ac.jp
†Corresponding author: tadano@me.saga-u.ac.jp

Abstract

A scale dependency of plastic deformation, i.e., a smaller crystal grain provides a higher flow stress, is an important characteristic of metallic materials. From both the theoretical and experimental viewpoints, it is known that dislocation structures at crystalline scale play an important role in the scale effect. Incorporating a higher-order gradient effect is an efficient way to introduce a scale effect into a crystal plasticity framework. In the higher-order gradient plasticity, an additional governing equation expressing the dislocation field is introduced. Kuroda and Tvergaaard proposed a higher-order crystal plasticity model, in which the dislocation density field was introduced as an additional unknown variable [1]. Finite element method is generally used to solve this type of constitutive model; however, it was reported that a kind of combination of finite elements for displacement and dislocation density fields led to failure of numerical analysis and a special treatment may be required for solving both fields simultaneously [2].

This study validates the possibility of a meshfree method to analyze the higher-order gradient crystal plasticity. The reproducing kernel particle method (RKPM) is introduced, and the stabilized conforming nodal integration (SCNI) [3] is adopted. The SCNI generally shows a higher performance than the conventional Gauss quadrature; however, no study on the accuracy of the SCNI in the higher order gradient plasticity, which constitutive equation is not a hypo-elasticity type, is reported. Several numerical examples are demonstrated, and a numerical performance of the SCNI in the higher-order gradient plasticity is assessed.

Keywords: **Meshfree Method, Higher-order Crystal Plasticity, Nodal Integration.**

References

[1] Kuroda, M. and Tvergaard, V. (2008) A finite deformation theory of higher-order gradient crystal plasticity, *J. Mech. Phys. Solids* **56**, 2573–-584.

[2] Kuroda, M. (2011) On large-strain finite element solutions of higher-order gradient crystal plasticity, *Int. J. Solids Struct.* **48**, 3382–3394.

[3] Chen, J.S., Wu, C.T., Yoon, S. and You, Y. (2001) A stabilized conforming nodal integration for Galerkin mesh-free methods, *Int. J. Numer. Meth. Engng* **50**, 435–466.