A numerical model formulation of the higher order flow theory (rate-independent) by Fleck and Willis [2009. A mathematical basis for strain-gradient plasticity theory – part II: tensorial plastic multiplier. Journal of the Mechanics and Physics of Solids 57, 1045-1057.], that allows for elastic–plastic loading/unloading and the interaction of multiple plastic zones, is proposed. The predicted model response is compared to the corresponding rate-dependent version of visco-plastic origin, and coinciding results are obtained in the limit of small strain-rate sensitivity. First, (i) the evolution of a single plastic zone is analyzed to illustrate the agreement with earlier published results, whereafter examples of (ii) multiple plastic zone interaction, and (iii) elastic–plastic loading/unloading are presented. Here, the simple shear problem of an infinite slab constrained between rigid plates is considered, and the effect of strain gradients, strain hardening and rate sensitivity is brought out. For clarity of results, a 1D model is constructed following a procedure suitable for generalization to 2D and 3D.