Mesh-Size Sensitivity for Reinforced Concrete: a Case Study

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Abstract

The smeared crack approaches, which represent the material cracking and degradation by using continuum constitutive laws with softening, are widely used in engineering community due to their simplicity. However, the mesh sensitivities are often encountered in computational practice. To overcome this problem, many methods are proposed, for example, the discontinuous method, the nonlocal method, and the crack band method. Although the discontinuous method and the nonlocal method are extensively investigated currently, the crack band method is still widely accepted due to its balance between accuracy and efficiency. According to the crack band method, the softening stress strain law is often related to the fracture energy and the characteristic length of finite element. The mathematical formulation to regularize the stress-strain relation based on fracture energy and mesh size could be found in the celebrated works of Bazant [1]. For plain concrete and other quasi-brittle materials, the crack band method works very well, and the mesh size dependence could be suppressed in many cases.

In the engineering practice of civil engineering, concrete often works with steel or other reinforcement to improve its performance. The reinforcement not only enhances the strength and ductility of the composite material but also changes the crack pattern and spacing for concrete itself. Thus the mesh dependence for reinforced concrete should be different from plain concrete, because the steel reinforcement may play as localization limiter. In this scenario, the conventional crack band model which applies for plain concrete may not work, and the method to tackle the mesh sensitivity of RC is missing. In the preset work, a numerical case study is performed to clarify the problem of mesh sensitivity for RC. The RC shear wall member with sufficient experimental data is adopted as simulation target. Damage model and plasticity model are adopted to reproduce the material nonlinearities for concrete and steel reinforcement, respectively. Systematic numerical simulations are performed with different mesh sizes and stress-strain relations. Finally, the semiempirical formulas of crack band theory to remove the mesh size dependence of reinforced concrete is developed based on numerical results.

Keywords: reinforced concrete, shear wall, smeared crack approach, mesh sensitivity.

References

[1] Bazant, Z.P. and Planas, J. (1998) *Fracture and Size Effect in Concrete and Other Quasibrittle Materials*. CRC Press, Boca Raton, USA.