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# 砂的临界状态本构模型局部化分叉分析

# Bifurcation analysis of strain localization by critical state model for sands

**中文关键词:** 临界状态 本构模型 砂 分叉 数值模拟 平面应变

**英文关键词:** critical state constitutive model sands bifurcation numerical simulation plane strain

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**中文摘要:**

基于砂的临界状态本构模型考虑了平均有效应力水平及孔隙比的影响，能合理地反映不同密度和应力水平下砂的变形特性。该模型对平面应变状态下变形局部化分叉的解析表明：在围压一定时，分叉出现在应力应变关系硬化阶段，分叉点对应的应力比及剪切带倾角均随孔隙比的增加而减小；密砂及松砂分叉点对应的应力比分别在临界状态线的上侧和下侧；而且峰值应力比与分叉应力比差值基本不变，但松砂较密砂差值大。在初始孔隙比一定时，密砂分叉点对应的应力比及剪切带倾角随着初始有效围压的增大而减小，而松砂分叉时的应力比及剪切带倾角基本不受围压影响。最后，为了验证解析解的正确性，采用回映应力更新算法，编写了有限元材料子程序，把该模型嵌入有限元软件ABAQUS。通过对多单元立方体试样数值模拟结果与解析解的对比，两者基本一致。

**英文摘要:**

The occurence of strain bifurcation is dependent closely on the used constitutive model and values of model parameters. The critical state model for sands can describe the stress-strain behaviour of loo-se, medium and dense sands, with mean stress level and void ratio being considered. In this paper the bifurcation solutions to a critical state model established by Yao et al （2004） in different init-ial void ratios and initial confining pressures are obtained. The theoretical analysis shows that, when the initial con?fining pressure is fixed, bifurcation for medium, dense and loose sands occurs in hardening regime. Bifurca?tion stress ratio and inclination angle of shear band decreases with increasing initial void ratio, and stress ratio at bifurcation is greater than the slope of the crit-ical state line（CSL） for medium and dense sands, but less than that for loose sands. The diffe-rence in stress ratio between peak and bifurcation is almost the same for medium, dense or loose sands, but is greater than that for loose sands. With the initial void ratio being fixed, bifurcation stress ratio and inclination angle of shear bands for medium and dense sands decrease with the incr-ease of initial confining pressure, but they are nearly unchanged for loose sands. Finally, the ret-urn mapping algorithm is adopted in order to implement the model into nonlinear finite element anal-ysis software ABAQUS through the user material subroutine（UMAT）interface. The numerical simulation for a cubic specimen at different initial void ratios and confining pressures are carried out, and the results show that the numerical results agree with the theoretical solutions well.

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