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压力相关弹塑性Cosserat连续体模型与应变局部化有限元模拟

李锡夔1，唐洪祥2

(1. 大连理工大学 工业装备结构分析国家重点实验室，辽宁 大连 116024；2. 大连理工大学 土木水利学院，辽宁 大连 116024)

摘要 提出了一个压力相关弹塑性Cosserat连续体模型。具体考虑非关联Drucker-Prager屈服准则，应力和应变速率向量的偏量和球量部分分离，在Cosserat连续体模型的框架下，推导出压力相关弹塑性Cosserat连续体本构模型的一致性算法：率本构方程积分的返回映射算法和压力相关弹塑性切线本构模量矩阵的闭合型显式表示。避免了计算切线本构模量矩阵时的矩阵求逆，保证了模型的数值求解过程的收敛性与计算效率。利用所发展的模型和有限元法，对应变软化引起的平面应变问题中的应变局部化现象进行了数值模拟。数值模拟结果表明，所发展的模型能保持应变局部化边值问题适定性、再现应变局部化问题特征：塑性应变局限于局部处急剧发生和发展以及随塑性变形发展的整体承载能力下降等方面的性能。

关键词 数值分析；Cosserat连续体模型；压力相关弹塑性；一致性算法；应变局部化

分类号

PRESSURE-DEPENDENT ELASTO-PLASTIC COSSERAT CONTINUUM MODEL AND FINITE ELEMENT SIMULATION OF STRAIN LOCALIZATION

LI Xi-kui1，TANG Hong-xiang2

(1. State Key Laboratory of Structural Analyses for Industrial Equipment，Dalian University of Technology，Dalian 116024，China；
2. School of Civil and Hydraulic Engineering，Dalian University of Technology，Dalian 116024，China)

Abstract
A pressure-dependent elasto-plastic Cosserat continuum model is presented. The non-associated Drucker-Prager yield criterion is particularly considered. The scalar product of the stress rate and the strain rate is decomposed into the deviatoric and the spherical parts，and the consistent algorithm，such as the return mapping algorithm for the integration of the rate constitutive equation and the closed form of the consistent elasto-plastic tangent modulus matrix，of

the pressure-dependent elastoplastic model is derived in the framework of Cosserat continuum theory. The matrix inverse operation usually required in the calculation of elasto-plastic tangent constitutive modulus matrix is avoided，which ensures the second-order convergence rate and the computational efficiency of the model in numerical solution procedure. The strain localization phenomena due to the strain softening are numerically simulated by using the developed model with corresponding finite element method. Numerical results of the plane strain examples illustrate that the capability and performance of the developed model in keeping the well-posedness of the boundary value problems with strain softening behavior incorporated and in reproducing the characteristics of strain localization problems，i.e.，the problems of intense straining development of localization in narrow bands and decreasing load-bearing capacity of the media with developments of the plastic strains.

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