[打印本页]　[关闭]

斜坡稳定性与地质灾害

一维泥石流的静动力阻力特征研究及数值模拟

樊赟赟[①], 王思敬[①②], 王恩志[①]

①清华大学 水沙科学与水利水电工程国家重点实验室 北京 100086;
②中国科学院 地质与地球物理研究所 北京 100029

摘要：

泥石流是山区多发的一种地质灾害,它的发生和发展威胁着人们的生命和财产安全,影响着人们的正常生活,因而需要加强对其发生和发展过程的研究。结合泥石流的动力模型方程采用数值模拟方法再现泥石流发生和发展的过程,是研究和预测模拟泥石流灾害的有效手段。目前的动力模型方程大多只关注动力过程,却忽视了静动力过程的统一,这将导致在一些情况下产生错误的结果。本文研究了一维泥石流的静动力阻力特征,通过修正泥石流动力学方程的阻力项,得到了具有静动力统一特征的模型方程。并以Roe格式的近似Riemann解为基础,采用MUSCL线性重构方法建立了具有较高精度和分辨率的有限体积数值求解。具体算例的数值验证表明,方程阻力项的修正是合理的,所建立的数值求解也是稳定和有效的。

关键词： 泥石流　阻力特征　Roe格式

CHARACTERISTICS OF STATIC AND DYNAMIC RESISTANCE OF ONE-DIMENSIONAL DEBRIS FLOW AND ITS NUMERICAL SIMULATION

FAN Yunyun[①], WANG Sijing[①②], WANG Enzhi[①]

①State Key Laboratory of Hydroscience and Engineering,Tsinghua University,Beijing 100084;
②Institute of Geology and Geophysics,Chinese Academy of Sciences,Beijing 100029

Abstract:

Debris flow is one of the common mountain hazards and seriously threatens human lives and belongings and affects society development. Therefore,it is necessary to study more about its happening and development. The approach of combining the dynamic model equations with the use of the numerical methods can lead to in-depth understanding of the development of debris flow. This is an effective approach to study and forecast the debris flow disasters. However,a majority of the present dynamic model equations focus on the dynamic process,and ignore the combination of the static and dynamic process. In fact,this neglect may result in some mis-leading results under some condition. In this paper,the characteristics of static and dynamic resistance of one-dimensional debris flow are studied. By modifying the friction resistance term of the kinetic equation,the model equation is obtained for the uniform characteristic of static and dynamic. Based on the approximate Riemann solver of Roe scheme,the numerical solution with higher precision and resolution is achieved by use of MUSCL linear reconstruction.The numerical validation of an actual example proves the rationality of the modification of friction resistance term and the stability and effectivity of the developed numerical calculation.

Keywords: Debris flow   Characteristics   Static and dynamic resistance   Roe scheme

通讯作者：

作者简介：樊赟赟,主要从事水岩动力过程研究.Email:fyun1982@gmail.com

作者Email：

参考文献：

---

[1] Savage S B,Hutter K.Themotion of a finite mass of granular material down a rough incline
[J].Journal of Fluid Mechanics, 1989, 199 , 177～215.

[2] O Brien J S,Julien P Y,Fullerton W T.Two dimensional water flood and mudflow simulation
[J]. Journal of Hydraulic Engineering, 1993, 119 (2): 244～261.

[3] Wang G Q.Analysis on the debris flow surges
[J]. International Journal of Sediment Research, 1994, 9 (3): 166～175.

[4] Iverson R M,Denlinger R P.Flow of variably fluidized granular masses across three-dimensional
terrain: 1 Coulomb mixture theory
[J]. Journal of Geophysical Research, 2001, 106 (B1): 537～552.

[5] 王纯祥, 白世伟,江崎哲郎,三谷泰浩.基于GIS泥石流二维数值模拟
[J].岩土力学, 28 (7): 1359～1368.
Wang C X,Bai S W,Esaki Tetsuro,Mitani Yasuhiro.Gis based two dimensional numerical simulation of
debris flow.Rock and Soil Mechanics, 2004, 28 (7): 1359～1368.

[6] Denlinger R P,Iverson R P.Flow of variably fluidized granular masses across three-dimensional
terrain: 2 Numerical predictions and experimental tests
[J]. Journal of Geophysical Research, 2001, 106 (B1): 553～566.

[7] Patra A K,Bauer A C,Nichita C C.Parallel adaptive numerical simulation of dry avalanches over
natural terrain
[J]: Journal of Volcanology and Geothermal Research, 2005, 139 (1-2): 1～21.

[8] Jeyapalan J K,Duncan J M,Seed H B.Analyses of flow failures of mine tailings dams
[J]. Journal of Geotechnical Engineering, 1983, 109 (2): 150～171.

[9] Roe P L.Approximate riemann solvers parameter vectors and difference schemes
[J]. Journal of Computational Physics, 1981, 43 (2): 357～372.

[10] 柏禄海, 金生.带源项浅水方程的高阶格式研究
[J].水动力学研究与进展, 2009, 24 (1): 22～28.
Bai L H,Jin S.Study on high resolution scheme for shallow water equation with source terms.Journal of
Hydrodynamics(Ser.A), 2009, 24 (1): 22～28.

[11] Brufau P,García-Navarro P,V zquez-Cendón M E.Zero mass error using unsteady wetting-drying
conditions in shallow flows over dry irregular topography
[J]. International Journal for Numerical Methods in Fluids, 2004, 45 (10): 1047～1082.

[12] Osher S.Convergence of generalized MUSCL schemes.SIAM Journal of Numerical Analysis, 1996, 22
(5): 947～961.

[13] Hubbard M E.Multidimensional slope limiters for MUSCL type finite volume schemes on unstruc-tured
grids
[J]. Journal of Computational Physics, 1999, 155 (1): 54～74.

[14] Darwish M S,Moukalled F.TVD schemes for unstructured grids
[J]. International Journal of Heat and Mass Transfer, 2003, 46 (4): 599～611.

[15] 杨重存. 泥石流堆积形态分析
[J].岩石力学与工程学报, 2003, 22 (s2): 2778～2782.
Yang Z C.Analysis on accumulation state of debris flow.Chinese Journal of Rock Mechanics and
Engineering, 2003, 22 (s2): 2778～2782.

[16] 王光谦, 倪晋仁.波状泥石流运动特性分析
[J].泥沙研究, 1994,(4): 1～9.
Wang G Q,Ni J R.Analysis on the characteristics of debris flow surges.Journal of Sediment
Research.1994,(4): 1～9.

本刊中的类似文章

(1): 91-

4．樊赟赟 王思敬　王恩志.基于结构两相阻力分析的泥石流堆积形态研究[J]. 工程地质学报, 2010,18(1): 100-

5．余斌,杨永红,苏永超,黄文杰,王高峰　.甘肃省舟曲8.7特大泥石流调查研究[J]. 工程地质学报, 2010,18(4): 437-444

6．许强.四川省8·13特大泥石流灾害特点、成因与启示[J]. 工程地质学报, 2010,18(5): 596-608

7．张妮, 梁收运, 钟秀梅.泥石流类型与地貌分形特征的关系研究[J]. 工程地质学报, 2010,18(5): 664-668

8．余斌, 马煜, 吴雨夫.汶川地震后四川省绵竹市清平乡文家沟泥石流灾害调查研究[J]. 工程地质学报, 2010,18 (6): 827-836

文章评论

反馈人		邮箱地址	
反馈标题		验证码	0534