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EDITORIAL

Introduction to the Special Issue on Modeling and Simulation of Fluid Flows in Fractured Porous Media: Current Trends and Prospects

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Understanding the fluid flow mechanisms in fractured porous media plays an important role in many engineering activities, such as nuclear waste disposal, geothermal energy extraction, oil and natural gas production, as well as performance and safety of underground projects including coal mines and tunnels. In recent years, many methods including numerical simulation, laboratory experiment and theoretical analysis have been employed to investigate the flowing process and permeability response of rock mass and rock fractures, from kilometer scale to microscale. However, the rocks/coals are in deep underground that is very complex and exists some uncertainties. Therefore, new numerical simulation methods and deep explanations of fluid flow behaviors in fractured porous media are still needed [1–3]. Thus, the guest editors organized a special issue on "Modeling and Simulation of Fluid flows in Fractured Porous Media: Current Trends and Prospects" within *Computer Modeling in Engineering & Sciences*. This special issue aims at presenting recent advances and challenges in studies on the 3D fracture network reconstruction, fluid flow modeling and permeability estimation of rock fractures, with the potential topics including intelligent and secure face recognition system in smart cities, reconstruction of 3D rock fractures and permeability estimation, fluid flow and solute transport in fractured porous media, flow regime transition modeling in complicated fracture networks, usages of 3D printing, micro-CT scanning and scanning electron microscope (SEM) techniques, fracture shear behavior and shear-flow process, effects of thermal treatment on dynamic and physical properties of rocks, and stability control modeling of underground surrounding rocks.

During the open period of the special issue, a total of 37 active manuscripts were received from various influential universities and research institutions. For each submission, we invited at least 4 well-known peer experts, and after a strict review process, only 12 research articles were finally accepted for publication, with the acceptance rate of manuscripts less than one third. These published papers cover the most advanced numerical calculation methods and applications for fluid flowing through fracture surfaces, fracture shear behaviors, stability control of underground surrounding rocks. The published 12 research articles can be classified into 3 groups, with the corresponding brief summaries presented as follows.

The first group consists of 5 papers that devote to the numerical modeling of fluid flow analysis, permeability prediction, and water-inrush mechanisms of rock fractures. Yin et al. [4] carried out an experimental and numerical study to investigate the solute removal process through a large-scale fracture plane with respect to various flow paths and hydraulic head differences in the paper titled "Solute removal analysis of a large-scale fracture plane considering different flow paths and different hydraulic head differences." The solute removal process, flow velocity fields, flow streamlines, as well as the hydraulic pressure fields were analyzed with the finite element software COMSOL multiphysics. Wang et al. [5] established a machine learning method integrating the random forest (RF) and the genetic algorithm (GA) to predict the permeability of Xishan coalfield in China based on uniaxial compressive strength, effective stress, temperature and gas pressure in the paper titled "Prediction of permeability using random forest and genetic algorithm model." The proposed hybrid model (RF-GA) is capable of predicting permeability and thus beneficial to precise coalbed methane recovery. Ejaz et al. [6] used Tehwari and Dass model for the impact of a magnetic field on Non-Newtonian nanofluid flow in the presence of injection and suction in the paper titled "Thermal analysis of MHD non-Newtonian nanofluids over a porous media." Some simulations of partial differential equations were also shown using software for graphing surface plots of velocity profile and streamlines along with surface plots and isothermal contours of the temperature profile. Yang et al. [7] used the smoothed particle hydrodynamics (SPH) method to simulate and analyze the rock breaking process by Sc–CO_2 jet based on the derivation of the jet velocity-density evolution mathematical model in the paper titled "Numerical study on rock breaking mechanism of supercritical CO_2 jet based on smoothed particle hydrodynamics." The study provides a theoretical guidance for further study on Sc–CO_2 fracturing mechanism and rock breaking efficiency. Lin et al. [8] analyzed the effect of the karst collapse column influence zone's width and the entry driving distance of the water inrush through the fractured channels of the subsided floor karst collapse column, by using the stress, seepage, and impact dynamics coupling equations in the paper titled "Analysis of a water-inrush disaster caused by coal seam subsidence karst collapse column under the action of multi-field coupling in taoyuan coal mine." Hysteretic water inrush disasters are related to the stress release rate of the surrounding rocks under the entry driving.

The second group of papers concern the experimental simulation and numerical modeling of deformation and damage of rock or rock fractures during shear. Zhang et al. [9] numerically constructed multi-holed coal specimens and calibrated based on UDEC-GBM models, and the mechanical properties and failure behaviors of the porous specimens were analyzed in the paper titled "Effect of hole density and confining pressure on mechanical behavior of porous specimens: an insight from discrete element modeling." This research promotes a good understanding of the effects of hole density and confining pressure on failure and mechanical behavior of porous geomaterials. Yang et al. [10] investigated the deformation and damage evolution of sandstone after heat treatment through laboratory confined compression tests and numerical simulations in the paper titled "Experimental simulation and numerical modeling of deformation and damage evolution of pre-holed sandstones after heat treatment." From 20°C to 200°C, thermal effect may promote shear damage and restrain tensile damage, while from 200°C to 800°C, thermal effect promotes tensile damage and restrains shear damage. Zhu et al. [11] investigated the impacts of sample geometric dimensions on shear behaviors in a punch shear test and numerical simulations using the Particle Flow Code in the paper titled "Impacts of disk rock sample geometric dimensions on shear fracture behavior in a punch shear test". The effects of three geometric dimensions including the disk diameter, ratio of shear surface diameter to disk diameter, and ratio of disk height to shear surface diameter on the shear fracture behavior were respectively discussed.

Zhang et al. [12] investigated the permeability and heat transfer enhancement mechanism of the hot-dry-rock (HDR) mass under the effect of shearing through theoretical analysis, experimental research and numerical simulation in the paper titled "Shear induced seepage and heat transfer evolution in a single-fractured hot-dry-rock." Balancing the hydroshearing enhanced heat extraction efficiency and shortened EGS reservoir lifespan would be significant to the sustainable development and utilization of geothermal energy.

The third group consists of 3 papers, which are related to the stability control modeling of underground surrounding rocks. Zhu et al. [13] experimentally and numerically investigated the anchorage properties, bolt force evolution, deformation and stress fields of blocky rock mass with various dip angles of joint surfaces under an applied axial load in the paper titled "Experimental and numerical study on anchorage strength and deformation properties of blocky rock mass." Not only the role of bolt support transfers the blocky rock mass to be a three-dimensional stress state through compression effects, but also it improves both tensile strength and shear resistance of both joint surfaces and the overall blocky rock mass. Shi et al. [14] established the compatible deformation model to investigate the quantitative relationship between the deformation of the coal seam wall and the gob-side wall and the subsidence of the lateral cantilever, and revealed the instability judgments for the coal seam wall and gob-side wall in the paper titled "Stability control of gob-side entry retaining in fully mechanized caving face based on a compatible deformation model." The field monitoring results showed that the blasting roof cutting method could effectively control the large deformation of surrounding rocks, which provided helpful references for coal mine safety production under similar conditions. Wang et al. [15] proposed a three-dimensional axisymmetric velocity field for roof collapse of shallow cavities in multi rock layers, by considering the influences of roof cross-section shapes, supporting pressure, ground overload, etc. The internal energy dissipation rate and work rates of external forces corresponding to the velocity field were computed by employing the Hoek-Brown strength criterion and its associated flow rule in the paper titled "Three-dimensional collapse analysis for a shallow cavity in layered strata based on upper bound theorem." The conclusions may provide workable guidelines for the support design of shallow cavities in layered rock strata practically.

The guest editors thank for the contribution of the authors, and are very glad to share the research findings obtained from the above published papers in this special issue. We believe that the advanced numerical modeling and experiment methods, as well as the related theories would be of great value to later research works of readers and peer experts. Furthermore, the guest editors sincerely hope this special issue can provide a platform for bringing researchers together to exchange the latest ideas, and to promote further collaborations in the community.

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