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EDITORIAL BOARD

Optimal operation of flood control for cascade reservoirs based on Parallel Chaotic Quantum Particle Swarm Optimization

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Abstract: The optimal operation of flood control for cascade reservoirs is a huge-scale complex nonlinear problem, involving a large number of decision variables and complicated constraints, and there are complex coupling relationship among water level and flow rate in each reservoir and each time with high dimension, nonlinear, strong constraint characteristics. Therefore, the evolution with traditional methods are difficult to directly solve or have low computational efficiency with premature convergence. This research tried to adopt Quantum Particle Swarm Optimization (QPSO) for cascade reservoirs optimal operation of flood control, and in order to improve the convergence effect and global search capability of QPSO, three improvements were presented for QPSO, such as population initialization with chaotic theory, adaptive activation mechanism and chaotic local search for elite particles. Furthermore, with the aim of reducing the computational time, a multi-core parallel computation technology was also employed. Overall, on the basis of above three improvements and multi-core parallel computation technology, Parallel Chaotic Quantum Particle Swarm Optimization (PCQPSO) was proposed in the paper. Then test function demonstrated the practicability, stability and high effectiveness of PCQPSO. Finally, the case study based on PCQPSO shows that PCQPSO is fast convergence efficiency, high precision, and the outcomes of this research based on PCQPSO offer new insights to carry out an efficient strategy for optimal operation of cascade reservoirs flood control.

Key words: cascade reservoirs; flood control optimal operation; Quantum Particle Swarm Optimization; chaotic search; multi-core parallel computation

Slope stability analysis by considering rainfall infiltration in multi-layered unsaturated soils

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Abstract: Rainfall is one of the major causes for slope failures. Rainfall infiltration reduces the slope resistance by largely lowering the matrix suction. The paper presents a method slope stability analysis of multi-layered unsaturated soils. Firstly, the Green-Ampt infiltration model is improved to calculate the infiltration depth in multi-layered unsaturated soils. Then, the soil strength parameters are estimated with consideration of rain infiltration. Finally, stability analysis is conducted by using of strength reduction method with ABAQUS. The method is applied to the case study of the Dafushan landslide in Guanzhou and found that the shallow slip surface in the simulation is close to the real case. Slope stability analyses are further conducted with different rainfall intensity and lasting period. It is found from the analysis that the slide surface is most probably located in wetting front or at the interface between the soils and bedrock. The long term and low density antecedent rainfall makes larger infiltration depth and deep seated slope failure; the short term and high density antecedent rainfall usually cause smaller infiltration depth and shallow seated slope failure; with the increase of rainfall intensity, rainfall duration, the infiltration depth increases, and then aggravate the slope failure.

Key words: rainfall infiltration; unsaturated soils; infiltration depth; strength parameters; slope stability

Mesoscale numerical analysis on moisture transport in cracked concrete subjected to drying–wetting cycles

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Abstract: For the splash and tidal zone of marine concrete structures, there are two main existing forms of the moisture involving both gas and liquid phases, which exist within the pores of concrete. Based on the unsaturated flow theory of capillary absorption by concrete, the one-dimensional nonlinear differential equation for moisture transport in cracked concrete subjected to drying–wetting cycles is developed. With consideration of the transport hysteresis during drying and wetting period, the models accounting for moisture transport coefficients during this process in an individual crack are respectively proposed. In terms of the mesoscale methodology that the cracked concrete is treated as a four-phase composite material consisting of coarse aggregate, mortar, interfacial transition zone (ITZ) and crack, the two-dimensional lattice network model with a single crack is adopted to conduct the numerical simulation of moisture transport in cracked concrete subjected to drying–wetting cycles. Compared with the existing experimental results, the proposed models are utilized to verify the transport theory of drying–wetting cycle in cracked concrete. Furthermore, by means of the above numerical models, the effect of drying–wetting cyclic mechanism (i.e., the ratio of drying–wetting time and cyclic times) and crack width on water distribution of cracked concrete are numerically carried out and reasonably analyzed. The numerical results suggest that water content distribution profiles within the crack and in the location perpendicular to crack direction depend on the ratio of drying–wetting time and cycles for the constant crack width. For the crack width ranging between 0.05–0.3mm, water content within the crack and perpendicular to crack direction decreases with the increase of crack width.

Key Words: drying–wetting cycles; cracked concrete; moisture; mesoscale lattice model; crack width

Contribution of hydrological and biological processes to nutrient retention in an agricultural headwater stream predominated by *Phragmites australis*

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Abstract: To examine the contribution of hydrological and biological processes to nutrient retention in a headwater stream with growing lots of aquatic macrophytes, eight field tracer experiments were conducted at an agricultural headwater stream reach, predominated by *Phragmites australis*, in the Nanfeihe River from September 2014 to June 2015. Such three typical hydrodynamic parameters as Reynolds numbers (*Re*), Froude numbers (*Fr*), and Manning roughness coefficient (*n*) of stream flows were calculated firstly according to the hydraulic data. Subsequently, both the practical and relative contributions of hydrological and biological processes to NH_4^+ and PO_4^{3-} retention as well as the total retention ratios of the two nutrients were estimated quantitatively. Study results show that the stream reach displayed striking turbulence characteristics over the eight tracer experiments and its flow status belonged to subcritical flow. The values of *n* ranged from 0.066 to 0.112, with a mean value of 0.089. The proportional NH_4^+ and PO_4^{3-} retention ranged from 9.17% to 28.27% and 5.75% to 17.79%, with the averages of 14.68% and 12.53%, respectively. The practical contribution rates of hydrological and biological factors to NH_4^+ retention were 10.12% and 4.57%, respectively, and 10.12% and 2.41% for PO_4^{3-}, respectively. The relative contributions of hydrological and biological processes to NH_4^+ retention were 72.51% and 27.49%, respectively, and 81.42% and 18.58% for PO_4^{3-}, respectively. The findings mentioned above indicate that hydrological process has a greater impact on the retention of NH_4^+ and PO_4^{3-} for the studied stream reach. Moreover, relationship between the hydrodynamic parameters (i.e. *Q*, *Re* and *Fr*) and the Manning roughness coefficient (*n*) could be expressed by using power functions, but no obvious relationship has been found between the practical retention ratio (i.e. η_{NH4}, η_{PO4}) and the following hydrodynamic parameters as *n* and *Re*.

Key words: agricultural stream; nutrient retention; aquatic macrophyte; tracer experiment; hydrodynamic parameter

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Characteristics of Nitrate-N losses through runoff and hydrological tracing in subtropical agricultural catchments

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Abstract: In order to understand the hydrological pathways of nitrate-N in subtropical agricultural catchments, this study was carried out at a nested agricultural headwater catchment in Hilly area of purple soil. Rainfall, discharge, $\delta^{18}O$, nitrate-N were monitored continuously in two storms. End member mixing analysis (EMMA) model was applied to quantify the contributions from different water sources. The results show that: (1) Surong catchment has the highest nitrate-N concentrations, while Wanan has the lowest nitrate-N, indicating that nitrate-N decreased with lager catchment size attribute to water dilution effect from other small watersheds which are dominated by woodland; (2) Subsurface flow from sloped croplands contributes to peak nitrate-N concentrations increased during the recession period of storm flow. The results of EMMA show that both$\delta^{18}O$ and nitrate-N successfully traced subsurface flow replenishment process during the flow recession period. But intense human activity might lead a certain deviation. In sum, nitrate-N has the potential to be environmental indicator and hydrologic tracer simultaneously during storm events for small agricultural catchments. But its application in more storm events at multiple sites remains to be further validated.

Key words: agricultural catchments; nitrate-N; storms runoff; hilly area of purple soil; hydrological tracing

Changes in the turbulent characteristics for sediment bed coated by biofilm

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Abstract: Biofilm growth on the sediment bed will change the turbulent characteristics and influence the sediment incipient, suspension and transportation. In this study, sediment with median size $d_{50} < 0.1$mm is used to investigate the change of turbulent characteristics with and without biofilm coating on the bed under the same discharge. Acoustic Doppler Velometer(ADV) is used to obtain the instantaneous velocity in the vertical direction. Mean velocity, Reynold stress, turbulent intensity distribution and bursting events above the bed are analyzed and compared between the biofilm-coated bed and the bed without biofilm, the influence of which on the sediment transportation is also discussed. Results show that with biofilm coated, the mean velocity in vertical direction increase and the bed resistance decrease, Reynold stress and turbulent intensity also decrease near the bed, which may change the vertical distribution of suspended sediment. Bursting events analysis shows a disadvantage of sediment incipient by the coated biofilm.

Key words: sediment transport; biofilm; turbulent characteristic

Research on river health assessment based on different biological assessmblages

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Abstract: In this study, a multimetric index based on fish and macroinvertebrate at the levels of community structure and function for the Hun-Taizi River basin (MMI-HT) was developed to assess river health. First, an index of land use, water and habitat quality (ILWHQ) was calculated to evaluate the environmental quality in the studied sites. Then, core metrics were selected using a stepwise procedure (the analysis of the range of index value distribution, stepwise regression analysis, Pearson correlation) that evaluated metric stability, responsiveness to stressors. Finally, ration scoring method was used to score multimetric index in the Hun-Taizi River(MMI-HT). Eight metrics (Cyprinidae species, Proportion of benthic species, Proportion of omnivore species, Proportion of individuals as tolerant species, Proportion of demersal eggs species, Proportion of individuals as demersal eggs species, EPT, Proportion of clingers) were selected to construct MMI-HT. Generally, macroinvertebrate metrics were more sensitive to coarse substrate, electric conductivity and suspended solid, whereas, fish metrics were more sensitive to fine substrate, dissolved oxygen, chloride, nitrogen, Permanganate index, water temperature, land use and perturbations of hydrological processes. Two groups responded differently to multiple stressors. The results showed that nine sites were in excellent condition, six were in good condition, seven in normal condition, seven in poor condition, and six in very poor condition in the Taizi River basin. There was no site in excellent condition, five in good condition, four in normal condition, five in poor condition, and five in very poor condition in the Hun River basin. These findings indicate that ecosystem health is worse in the Hun River than that in the Taizi River.

Key words: multimetric assessment; fish; macroinvertebrate; land use index; river

Mechanism of the intermittent motion of two-phase debris flows head and the energy character

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Abstract: A typical two-phase debris flow exhibits a high and steep flow head consisting of rolling boulders and cobbles and intermittent or fluctuating moving velocity. The relative motion between the solid phase and the liquid phase is obvious. The motion of a two-phase debris flow depends on not only the rheological properties of the flow, but also the energy transmission between the solid and liquid phases. In addition to the rheological characteristics of two-phase debris flow, energy transfer between liquid phase and solid phase plays an important role. Energy analysis method was used to study the energy transfer mechanism between the two phase flows and simulate the motion of two-phase flow. This paper analyzed the intermittent feature of two-phase debris flows based on videos of field debris flows and flume experiments. The experiments showed that the height of the head of the two-phase debris flow increased gradually at the initiation stage and reached equilibrium at a certain distance. The height growth and the velocity of the flow head showed fluctuating characteristics. Physical equations were established and the analyses proved that the average velocity of the two-phase debris flow head was proportional to the gully slope and flood discharge, and inversely proportional to the volume of the debris flow head.

Key words: two-phase debris flow; intermittent motion; unsteady flow; flow power; energy dissipation.

Investigation on hydraulic transients in tailrace tunnel with air inlet and release from the vent

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Abstract: Based on the one-dimensional hydraulic transients and the method of characteristics (MOC), the mathematical model of the vent in the tail race tunnel is established by using the Discrete Free-Gas Cavity Model (DGCM), and the thermodynamic properties of the gas is taking into account as well. A corresponding numerical model has been developed using the data of a real hydropower station, and the phenomenon of air inlet- two phase flow-air releases is investigated during transient process. The results show that air inlet can effectively relieve the negative pressure in the tunnel, but air releases can lead to a large impact pressure, which comes from the water column rejoin after the separation by the air, resulting in the direct water hammer. When the area of the vent is large, the impact pressure decreases with the increase of the area, when the area of the vent is small, the impact pressure increases with the increase of the area. According to its characteristics, the structure of a new type of vent is presented, i.e., the vent is fully open when the air flows in, and the vent is partly open when the air flows out. When the air releases area is about 10% of the air inlet area, the pressure oscillation is small.

Key words: hydropower station; hydraulic transients; vent; tailrace tunnel; air pocket

Investigating the circle pipe's roughness with the fractal geometry theory and the practical application

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Abstract: The author analyzes the important effects of equivalent roughness K_S in calculating the friction losses of turbulent flow, based on the existing theoretical and experimental research achievements of resistance laws, as well as depicts the situation of calculating the friction losses and applicationin China's hydraulic engineering. For the case of circle pipe's roughness, the author researches on the fractal characteristics of roughness of pipe's inner wall with the fractal geometry theory, and gives the mathematical model of the fractal dimension and numerical examples. The author also demonstrates the relationship between the fractal dimension and equivalent roughness K_S, the calculation methods of fractal dimension of pipe roughness in longitudinal and transverse are discussed respectively, then gives way to apply the turbulent resistance laws and research achievements provided by the former to engineering practice directly.

Key words: fractal geometry; circle pipe; equivalent roughness; fractal dimension; friction losses

Fracture toughness of concrete after carbonation and wet-dry cycle of sulfate solution

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Abstract: In this paper, the effects of deteriorations is studied, such as carbonation and wet-dry cycle in sulfate solution, upon fracture toughness of concrete. Through the three-point bending test on the notched beams of concrete after carbonation and wet-dry cycle in sulfate solution, the effects of carbonation time (t) and wet-dry cycle number (n) upon the fracture toughness of concrete were studied. The results show that carbonation and wet-dry cycle deteriorate the fracture toughness to some extent. Degradation factor(R) is less than 1. Fracture toughness decreases as t (or n) increases. R significantly decreases as(or n) increases, and statistical analysis indicates that t and n meet the relation of exponential function with R respectively. Because of the obvious interaction between carbonation and wet-dry cycle, the individual effect of carbonation (or wet-dry cycle) is more serious than the alternate one. Based on the test results, the calculation model is established for calculating fracture toughness of concrete deterioration. This model is helpful to analyze the crack propagation and fracture toughness of concrete deterioration.

Key words: carbonation; sulfate solution; wet-dry cycle; concrete; fracture toughness

Bearing mechanism of reinforced concrete penstock with steel liner considering friction-contact behavior

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Abstract: Coulomb friction model is employed to simulate the friction-contact behavior between steel liner and reinforced concrete when a numerical model of reinforced concrete penstock with steel liner located on the downstream surface of concrete dam is built up. The critical pressure of concrete crack initiation, concrete crack propagation law, penstock deformation characteristic and stresses distribution of steel are analyzed upon the friction-contact model (FCM). Some impressive conclusions can be achieved from the results: the concrete crack propagation law of FCM meets the experiments' results well; the differences of tensile stress of the steel liner between the crown and the bottom are less than the traditional node shared model when FCM model is adopted; the width of the concrete crack of FCM model ranges from 0.3 to 0.4, larger than traditional node shared model; non-uniformities of both the displacement around the penstock crown and the steel liner tensile stresses increase with the friction while tensile stresses values and strain non-uniformities of the cross-crack-reinforcement decrease when the friction are larger. The results indicate that the rebar stresses are less while the non-uniform of liner stresses are greater when the combinations between steel liner and surrounding concrete are enhanced.

Key words: penstock; reinforced concrete penstock with steel liner; friction-contact behavior; bearing mechanism

Discrete and continuous coupling numerical simulation of the impact loading

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Abstract: Dynamic compaction and impact rolling have been widely used in hydraulic engineering (e.g. port engineering and dam engineering). The research about complex dynamic characteristics mainly depends on laboratory model tests and engineering experience, while the numerical method was rarely used. Combining the discrete element method (DEM) and finite difference method (FDM), a discrete and continuous coupling model was established to simulate dynamic compaction. The hysteretic damping model of the PFC^{2D} is used in the important area, while the surrounding area is simulated with Mohr-Coulomb model of FLAC^{2D}. According to the force equilibrium principle, the resultant force and bending moment acting on the boundary wall are distributed to the boundary node of continuous model. Due to the fact that the coupled boundary could not bear tensile stress, adjustment is made to transfer the boundary surface stresses, and the velocity of boundary wall is determined by the velocity of boundary node. The numerical results were compared with those of laboratory tests and the feasibility of the coupling simulation was validated, which provides a new method for dynamic improvement and stability analysis of dam and port.

Key words: impact load; discrete element method; finite difference method; discrete and continuous coupling; dynamic characteristics

Finite-element simulation and experiment on polymer directional fracturing and grouting for dykes and dams

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Abstract: Directional fracturing test was carried out by injecting polymer seriflux to some holes which were arranged along the axis of earth dam with a self-made directional fracturing drilling tool. The results show that the polymer seriflux could diffuse into prefabricated crack and fracture soil, and build an ultra-thin polymer anti-seepage wall about 2 to 3cm thickness by overlapping each other which has closely bonds with the surrounding soil, forming a composite impervious structure. The directional fracturing mechanism of the polymer grouting is simulated by using the bonding element method, the directional crack propagation length and opening width is basically consistent with the field test results. Thus an efficient method is presented for design in polymer directional fracturing grouting project of the dykes and dams.

Key words: directional fracturing; grouting; polymer; bond element