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Regional water resources allocation oriented to ET control in plain area

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Abstract: The potential changes are occurring in the Earth's water cycle due to climate change and human activities, which cause water supply system mainly affected by hydrological processes are extremely complex and variable. Water resources management based on water demand has been not an accurate reflection to the regional water resources status. It needs us develop water resources management from the perspective of water cycle. This study introduces the basic theory and method of water resources management based on evapotranspiration (ET) control, and put forward the ET-based model on county-territory scale and its calculation method. The ET-based model is different from the traditional method, origins from regional water cycle process and stresses the natural attributes of water resources. In addition, this study considers Luannan County with over-pumping groundwater and further discusses the case study about water resource allocation based on ET. The research shows the ET-based model chooses ET control as the means, cutting ET as the goal, physical drive processes of water resources as theoretical basis, and takes into account many practical problems related with county development such as the industrial development, planting structure, water-saving potential and excessive exploitation of water resources. The treatment can make the planning scheme from the model is accord with the actuality of regional development and give controlling the over-pumping exploitation of water resources more maneuverable.

Key words: water resources management; evapotranspiration; object ET; ET control; over-pumping groundwater

(责任编辑: 王成丽)

Research for impacts of boundary layer grid scale on flow field simulation results in pumping station

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Abstract: The y^+ value on a wall is a primary parameter of boundary layer grid scale, and has important influence on the flow field numerical simulation for pumping stations. In order to clarify the requirements of y^+ for different simulation objectives, a realistic pumping station was adopted and evaluated. Considering of meshing difficulty, numerical computation accuracy and efficiency, three kinds of numerical grid schemes were put forward based on the grid independence analysis. The three schemes were named global unstructured grid, global unstructured grid with specified boundary layer height, and block structure grid with specified boundary layer, respectively, which result in the corresponding value of y^+ 10~2000, 10~1000, 10~500. The results showed little difference in velocity distribution uniformity between scheme 2 and scheme 3. However, scheme 1 was comparatively large difference with the other two schemes. If the macro hydraulic performance of pump station is the main concern, a simple and easy grid scheme (scheme 1) could meet the satisfaction, y^+ value could be relaxed appropriately to 0~2000. If the vortex distribution in flow field is the main concern, y^+ should be less than 1000, the scheme 2 of gridding should be adopted. If the detailed flow structures, or vortex elimination devices become the main concern, y^+ must be within 30~500, and the scheme 3 is the best choice.

Key words: pumping station; flow field simulation; boundary layer grid scale; vortex

(责任编辑: 李福田)

Analysis on law of soil salt accumulation under condition of high salinity phreatic water evaporation in arid areas

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Abstract: Column experiments were carried out to investigate effects of total dissolved solids (TDS) (30g/L and 100g/L), vadose zone lithology (fine sand and silt clay) and depth of groundwater table (0.5m, 1.0m and 3.0m) on distribution of soil salt accumulation under condition of high salinity phreatic water evaporation in arid areas. Samples were taken seven times from different depths of column for soil salt analysis. The results indicate that under condition of high salinity phreatic water evaporation, the less depth the groundwater table is, the larger soil salinity at the same depth will be. Salinity in soil profile with vadose zone lithology of silt clay is higher than that of fine sand when other conditions are fixed. In addition, soil salinity of phreatic water with TDS of 30 g/L is higher than that with TDS of 100 g/L in the upper layer of silt clay column due to the membrane effect of tenacious soil and filling effect of crystal salt in soil pore, and lower in the lower part of the column. Depth of salt accumulation in silt clay profile tends to shift down with the increase of phreatic water TDS due to the change of capillary water gravity and soil structure as a result of higher TDS.

Key words: arid area; high salinity phreatic water; phreatic water evaporation; soil salt accumulation

(责任编辑: 韩 昆)

Kinematic characteristics of horseshoe vortex upstream of circular cylinders in open channel flow

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Abstract: To investigate the kinematic characteristics of horseshoe vortex upstream of cylinders, the swirling strength method is introduced to identify horseshoe vortices, and a method of fitting the local velocity field with an elliptic vortex are proposed to characterize these vortices. The elliptic vortex is constructed by overlapping the Oseen vortex with an inclined unidirectional shear flow. The proposed methods were used to investigate the time-averaged horseshoe vortex upstream of a circular cylinder in open channel flow. The time averaged horseshoe vortex is captured by averaging instantaneous velocity fields measured with PIV. The results show that, in flows with cylinder Reynolds number larger than 10^4 , the position of horseshoe vortex is unchanged while the upstream separation point moves downstream slowly. The distances from the vortex center to the cylinder axis and the bed are $0.67D$ and $0.06D$, respectively, with D being the cylinder diameter. Comparing with those in open channel flows, the horseshoe vortex and separation point in turbulent boundary layers are further upstream. With the increasing of cylinder Reynolds number, the horseshoe vortex strengthens itself but keeps the size unchanged, results in increasing shear stress on the bed. The dependence of vortex-induced shear stress with the flow strength indicates that it is physically reasonable to formulate equations for local scour based on the kinematic characteristics of horseshoe vortex.

Key words: flow around cylinder; horseshoe vortex; characteristic extraction; kinematic characteristics; particle image velocimetry

(责任编辑: 李福田)

Detection for non-stationary vibration signal and fault diagnosis of hydropower unit

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Abstract: In view of the traditional method is difficult to accurately detect non-stationary vibration signal of hydro-generator units and the low accuracy of existing vibration fault diagnosis methods, this paper introduced the permutation entropy algorithm for detection and analysis. And then realized feature extraction of non-stationary vibration signals based on multi-dimensional permutation entropy, so as to construct fault data samples; The diagnosis model of support vector machine (SVM) based on genetic algorithm is established, and the sample data is the input of the model, then the fault diagnosis and identification is completed. The simulation results show that permutation entropy can effectively detect the mutations of non-stationary vibration signals, and the fault diagnosis method based on MPE and SVM can effectively identify abnormal situation of the unit and achieve higher diagnostic accuracy.

Key words: hydropower unit; non-stationary; multi-dimension permutation entropy; support vector machine; faulty diagnosis

(责任编辑: 李福田)

Three-dimensional numerical simulation of curtain grouting in the dam bedrock based on binghamian grouts

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Abstract: Because of the grouting engineering of masking and the complexity of geological conditions, how to accurately determine the diffusion regularity of grout under complicated geological conditions is the key and difficult point of grouting numerical simulation analysis. Binghamian grouts two-phase flow characteristics in the process of grout diffusion and complex geological conditions of dam bedrock is not considered in the present numerical simulation research of grouting in the hydraulic engineering. These research objects mainly focus on a single fracture or a single grout hole, while the simulation of grout front has not involved. Aim at the above-mentioned problems, a three-dimensional refined geological information model, included different formations, unfavorable geological body, curtains, grouting holes, was firstly established in this paper. Then, coupled with the volume of fluid (VOF) method in the CFD commercial software STAR-CCM+, a three-dimensional grouting mathematical model of Binghamian grouts air-grout two-phase flow was developed to achieve the numerical simulation of the multiple holes and sequencing grouting in the dam bedrock, also analyzing the grout diffusion rule and curtain lap after grouting. Finally, a hydropower station of bedrock curtain grouting process was taken as a case. The results show that the grout diffusion radius increases with time in a certain time range, but its rate of change shows a decline trend. After grouting completion of each sequence hole, grout front laps well. Furthermore, comparing the simulation value with the actual measuring value of the grouting quantity and time, the average errors were 9.08% and 6.32% respectively, which verified the reliability of the method.

Key words: dam bedrock curtain grouting; Binghamian grouts; VOF method; three-dimensional air-grout two-phase flow grouting mathematical model; geological information model; multiple holes and sequencing

(责任编辑: 李福田)

Structure damage evolution and mechanical properties of loess by CT-triaxial test

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Abstract: A series of CT-triaxial tests of an intact unsaturated Q_3 loess and remolded loess were conducted using a stress controlled CT multi-function triaxial apparatus developed, and the changes of the internal structure was measured using CT technology. The distinctive CT images and detailed CT data were obtained during nondestructive of the loess, which explains meso-structure evolution of loess under triaxial shear failure conditions from the microscopic view. The results show that, With the increase of confining pressure, the curves of relationship between meridional stress and axial strain transformed into hardening from weak softening gradually. The curves of relationship of shear failure strain softening between body strain and axial strain transformed into contraction form from dilatation. The curves of relationship between CT number and average axial strain experience a slight increase first, then reduce gradually. The relation curves between average CT number and the axial strain of shear failure strain hardening type increase rapidly in the initial stage, and then slow growth in the shearing process. The failure process of remolded loess shear specimen in central shear damage smaller, crack mainly derived in the periphery of the samples. The performance of intact loess cementation zone gradually broken, empty area showed due to the slip granular soil around and gradually by compression. CT technology makes the soil meso-structure research to a quantitative stage, and provides the experimental basis for establishing the constitutive model of soil structure and structural evolution equations.

Key words: loess; meso-structure; damage; mechanical characteristics; CT-triaxial test

(责任编辑: 李 琳)

Stability analysis of hydro-turbine governing system of hydropower station with inclined ceiling tailrace based on Hopf bifurcation

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Abstract: Based on the Hopf bifurcation theory, the stability analysis of hydro-turbine governing system of hydropower station with inclined ceiling tailrace is studied. Firstly, the nonlinear mathematical model is established. This model contains the momentum equation of pipeline system which can accurately describe the motion characteristics of the interface of free surface pressurized flow in inclined ceiling tailrace. According to the nonlinear mathematical model, the existence and direction of Hopf bifurcation of nonlinear dynamic system are analyzed. Furthermore, the algebraic criterion of the occurrence of Hopf bifurcation is derived. Then the stability domain of hydro-turbine governing system is drawn by the algebraic criterion, and the characteristics of stability under different state parameters are investigated. Finally, the stability working principle of inclined ceiling tailrace in the condition of load adjustment is studied based on stability domain. The results indicate that the Hopf bifurcation of hydro-turbine governing system of hydropower station with inclined ceiling tailrace is supercritical. The variation of water inertia caused by free surface pressurized flow is favorable for the stability under load reduction, but it is unfavorable under load increase. However, the water-level fluctuation of free surface flow is always favorable for the stability under load reduction and load increase.

Key words: inclined ceiling tailrace; hydro-turbine governing; nonlinear system; stability; Hopf bifurcation

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Mesoscopic simulation of the mechanical properties and the size effect of reinforced concrete column subjected to axial compressive loading

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Abstract: The size effect behavior of reinforced concrete (RC) components is caused mainly by 1) the heterogeneity of concrete itself, and 2) the complex mutual effects between concrete and steel rebar. Considering of the mesoscopic heterogeneity, it is assumed that the steel rebar and concrete is well bonded. A series of meso-scale mechanical analysis models of RC columns subjected to axial compressive loading are set up. First, the mechanical parameters of the meso components are confirmed by an inversion method based on the simulation of compressive mechanical properties test of a concrete specimen. Then, the damage process of RC column subjected to axial compressive loading is simulated at macro- and meso-scale. The size effect of the nominal compressive strength of RC components is discussed. The mesoscopic simulation results of this work follows closely the test results. The rationality of the established mesoscopic analysis method for the research of size effect of RC components has been verified.

Key words: RC column; Size effect; Heterogeneity; Mutual effect; Mesoscopic mechanical model

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Experimental study of particle grading impact on piping mechanism

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Abstract: Combined with fine measuring equipment, vertical seepage sand piping tests were carried out through a self-designed model slot. The geometry and hydraulic parameters of soils and the particles movement characteristics are obtained during the tests to study the particle grading impact on piping development and to explore the mesoscopic mechanism of piping. In piping type soils, the gradation of movable particles does not affect the final particles loss fraction, while the maximum size and distribution law of loss particles are influenced. Whether the seepage failure occurs or not and the corrosion process are affected greatly by the movable particle content, and the critical content of movable particles and the self-filtering phenomenon should be considered fully. Through the stereo microscope, the self-filtering and self-stabilizing process internal the sand soil with critical content of fine particles is obtained during seepage from the mesoscopic view. It further reveals the interlayer value of D_{15}/d_{85} resulting from interaction of soil and water is in line with the self-stabilizing gradation characteristics, which leads to the system self-stabilizing. In order to discriminate the seepage failure mode and critical hydraulic gradient magnitude in the case of sand with wide grade distribution and lack of middle size, it is necessary to carry out experimental demonstration for the complex interaction of soil and water, according to the accrual grading feature of engineering soils and the hydraulic conditions based on the traditional judgment formula or experience curves.

Key words: sandy piping; small scale model; particle grading; leakage; interlayer value; interaction of soil and water

(责任编辑: 李 琳)

Reliability analysis on stability of gravity dam foundation over multiple sliding planes using PSO

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Abstract: Instability of foundation over multiple sliding planes is a general case occurring in bedrock under most engineering geological conditions of concrete gravity dams. But there are little literatures on extensively researching about this case. For simplification the instability probability was commonly evaluated using models of single or dual sliding plane(s) for the dam foundation. Base on the geometric interpretation of the reliability index, the reliability calculation can be treated as mathematical optimization, so the particle swarm optimization (PSO) can be used logically. A reliability calculating method on the basis of PSO is provided in the paper, which is applied to evaluate the stability reliability index of concrete gravity dam foundation over multiple sliding planes. By comparison with the calculated results by other methods for three testing examples and an actual dam, the method is verified to be accurate, efficient and rational, and can be utilized to the practical complex engineering, for which the performance function for reliability analysis is nonlinear and implicit. So the method will benefit the further research and provide good technical support on the stability safety assessment and structural design of gravity dam.

Key words: concrete gravity dam; reliability; particle swarm optimization; stability against sliding along deep-seated plane; multiple sliding planes

(责任编辑: 王冰伟)

Experimental model study on dam break and evolution law of tailings pond

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Abstract: According to the practical project, the tailings pond model was set up based on a self-developed dam-break model test system. The dam-break model test was carried out under the continuous rise of saturation line caused by the failure of drainage system in the tailing pond. In the tests, the dam break and evolution process of the tailings pond was observed and measured by the dam displacement measuring device, and the dam-break pattern and dam-failure mechanism were discussed. The results show that the type of dam break belongs to the reversed-stream and traction failure, and the dam break process can be approximately divided into three stages: (1) tension cracks appeared by the dam surface swamping, (2) soil flow failure and local collapse failure, and (3) extensive collapse failure and landslide failure. The first two stages are the induced phases of the collapse and landslide failure. Before soil flow failure the cracks appeared on the surface of the dam and the seepage water overflow from the dam. If the effective measure can be carried out to reduce the saturation line at first time, the extensive soil flow will be avoided. The collapse and landslide failure has the characteristics of larger break body and shorter duration, which is difficult to prevent. Comparison of the model test results with the numerical results and the prototype observed data, it is showed that the model test results are in well agreement with the others. The model test method in this paper could be used to predict and inverse the dam break process of tailings ponds.

Key words: tailings pond; dam break; model test; soil flow; landslide failure

(责任编辑: 祁 伟)

Experimental study on non-uniform bedload instantaneous transport rate

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Abstract: Bedload discharge is an important content of sediment movement mechanics. At present the study of bedload sediment transport rate mostly focused on time average rate, while instantaneous sediment rate is relatively fewer. Firstly, Ballio method for calculating uniform bedload instantaneous transport rate was introduced, and the improved Ballio method was derived to calculate non-uniform instantaneous transport rate. Secondly, the instantaneous velocity of different sediment particles was measured in flume experiment, and substituted into the improved Ballio formula, the instantaneous transport rate can be obtained. Then definition method was used to calculate the bedload instantaneous transport rate, compared with Ballio method, the results of two methods is relatively close. It is feasible the improved Ballio method used to calculate the non-uniform bedload instantaneous transport rate. Meanwhile, the characteristics of the non-uniform bedload instantaneous transport rate were revealed in this paper, such as instability on time, non-uniformity on space and the intermittency in the sediment movement process.

Key words: the instantaneous sediment transport rate; non-uniform bed load; sediment transporting characteristics; the flume experiment; Ballio method

(责任编辑: 李福田)

The sensitivity analysis of seven-parameter rockfill rheological model based on the orthogonal test method

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Abstract: The seven-parameter rockfill rheological model has been widely applied in the numerical calculation of stress and deformation of the concrete faced rockfill dam, but the sensitivity analysis for the parameters of the rheological model on the dam stress and deformation is not deep enough. Based on the orthogonal test method, the Gongboxia concrete faced rockfill dam is taken as an example in this paper to conduct the sensitivity analysis of seven-parameter rockfill rheological model with major test indexes of the maximum vertical settlement displacement of the dam V , the maximum deflection of the panel δ and the stress isograms of the panel along the slope σ . The results show that among the seven-parameters, for the indexes of V , δ and σ , the sensitivity of m_1 , b , m_2 are relatively larger, and m_1 is the largest, followed by b and m_2 ; while the parameters of α , c , d and m_3 have relatively small influence on each index. Therefore, when using the seven-parameter rockfill rheological model to analyse the rheology of concrete faced rockfill dam, m_1 , b and m_2 should be the key point in analyzing and selecting rheological parameters. The research methods and results of this paper can provide a reference for selecting the parameters for the seven-parameter rockfill rheological model of concrete faced rockfill dam.

Key words: rockfill materials; the orthogonal test method; sensitivity analysis; seven-parameter rockfill rheological model

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