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SHUILI XUEBAO

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Theory and study methodology of dualistic water cycle in river basins under changing conditions

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Abstract: Water cycle in river basins has been changed profoundly under the impacts of human activities and climate change. Scientific basis behind water issues such as flooding, water scarcity, water pollution and turbidity is evolutionary mechanism of water cycle and accompanied water environment and eco-hydrology processes. Therefore, it is desired to establish a set of nature-society dualistic water cycle theory to support effective solutions of these water issues. In this study, on the basis of brief description of dualistic water cycle research history, comparative analysis of different characteristics of natural water cycle and nature-society dualistic water cycle is performed from aspects of driving forces, structures, functions and reactions, and basic theory of nature-society dualistic water cycle has been put forward, which includes subjective mode, scientific issues, study contents and study methods etc. Opportunities and challenges confronted by the dualistic water cycle study are also discussed, e.g., issue and solution method of united measuring and transforming of quantity-quality-efficiency of water resources, and a study summary is given at last.

Key words: river basin; water cycle; natural water cycle; nature-society dualistic cycle; coupled human-natural systems

Spatial variance of soil phosphorus in the forest–dryland–paddy mode of Northeastern Mollisol watershed

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Abstract: Phosphorus (P) as one of the major nutrient elements for crops growth is easily resulting in environmental pollution after over application. In order to efficiently guide the fertilization and control the no–point pollution in agriculture, it is important to know the spatial variance of P and its main driving mechanisms. In this study, the effects of land use, topography, hydrology, crop pattern and other factors on the spatial pattern of TP (total phosphorus) and AP (Olsen–P) at a watershed scale were clarified using traditional statistics and geostatistics. The results show that both TP and AP have the moderate spatial autocorrelation and spatial variation, while the spatial variation of AP is greater than that of TP. Generally, the spatial distribution is different between TP and AP. TP is lower in the intersection of dryland and forestland, while AP is higher at the transitional zone of dryland and paddyfield. Both TP and AP are highest at the outlet of the watershed, and the average content is 0.8 g/kg and 60 mg/kg respectively. TP distribution in the watershed indicates that the influence of soil loss and deposition still existed after conversion from dryland into paddy field. In the dryland, TP content is relatively higher at summit and flat field while it is lower on the back slope and the bottom. This is mainly due to the influence of soil physiochemical properties and soil loss. In the forestland, both TP and AP are lower. Compared with flat dryland, TP is higher in paddy field, while AP is significantly lower by 26.1% in paddy field. Generally, the main factors influencing on P spatial distribution can be ascribed to fertilization (N and P), crop covers, land use, soil erosion and soil deposition, while the influence of position of river systems, villages and towns is insignificant. Additionally, when the AP is larger than 25 mg/kg, P is easily moved out of soil, especially at the transitional zone of paddy and dryland, intersection area of rivers, and the area near the outlet of watershed.

Key words: TP; AP; Ca–P; heterogeneity; soil nutrients; agricultural cleaner production

Stress classification based method for strength design of exposed steel penstocks in hydropower station

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Abstract: In order to adapt to the development on material, weld technology, fabrication and erection of the penstocks, and to consider the practical need on connection with international codes and engineering experience, the stress classification method, commonly used in design of exposed steel penstocks, was investigated systemically. The philosophy under the selection of structural calculation model and key cross sections are illustrated from the standpoint of bearing capacity and mechanism. In addition, the differences and similarities of the stress calculation methods for key cross sections among the domestic and foreign codes were compared. The reasonable stress classification is suggested in terms of failure mechanism and the stress formation based on the failure mechanism and the stress constitution in key cross sections. The corresponding safety level for the classified stresses was then recommended. The conclusion is drawn that different key cross sections are claimed while no obvious difference among the stress results calculated by the domestic and foreign codes, and the section close to supporting ring may not to be chosen as key section and the steel consumption is mainly determined by the admissible value of integral membrane stress. Using the recommended stress classification and safety level, material can be saved while ensuring structural safety.

Key words: exposed steel penstocks; strength design; stress classification; calculation model; key cross section; safety level

Geomorphic characters of debris flow fans along Nu River and the river blocking mechanisms

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Abstract: A large number of gullies along the Nu River are debris flow gullies, and most of them are two-phase debris flows gullies. A typical two-phase debris flow exhibits a high and steep flow head consisting of rolling boulders and cobbles and large resistance or low velocity, which is easy to form fan beside the Nu River. The size and density of flood fans are much lower than debris flow fans. Distinction of debris flow fans and flood fans is helpful to disaster reduction in mountain areas. Many debris flow fans completely blocked the Nu River and formed dammed lakes. There is almost one debris flow dammed lake per 10-20km at Nu River of Gaoligong Mountain gorge section. The Nu River of Gaoligong Mountain gorge section formed repeated sections of straight flow connecting Lake flow and weir dam. The debris flow gullies blocking river were main distributed in valleys area of 40km^2. The debris flow fans blocking the Nu River was main cause of sedimentation, and the sedimentary rate assessment in debris flow dammed lake was explored based on drill technology. Energy equations were established to analysis the mechanics of river blocking by the two-phase debris flow fans. Energy equations and field investigation showed that the velocity and volume of debris flow head from gullies were main causes to block the Nu River.

Key words: debris flow fan; Nu River; dammed lake; flood fan; energy dissipation.

Transpiration analysis based on water balance in a ground cover rice production system

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Abstract: Ground cover rice production system (GCRPS) has attracted great attention due to its contributions to both saving water and increasing yields. However, the water budget, especial for plant transpiration, in a GCRPS is still unclear. In this study, a two-year field experiment with nine treatments for three irrigation levels (TPRPS, traditional paddy rice production system; $GCRPS_{sat}$, keeping root zone average soil water content near saturated, and $GCRPS_{80\%}$, keeping root zone average soil water content as 80%~100% of field water capacity) and three nitrogen levels (N0, without nitrogen; N1, 150 kg N/ha with urea; N2, 75 kg N/ha with urea and 75 kg N/ha with chicken manure) was conducted in Shiyan, Hubei province, China. The transpiration during the six main growth stages of rice was analyzed in detail using water balance method. The results showed that: (1) Both physiological transpiration and non-physiological water consumption such as deep drainage and evaporation were significantly limited under GCRPS especially $GCRPS_{80\%}$, accompanied by similar or even higher yields; (2) Plant transpiration pattern was not affected significantly by water or nitrogen treatments during the entire growing season, and a "low-high-low" trend was found with a top at anthesis stage; (3) Plant transpiration was improved by the warming effect under GCRPS before max-tillering, and afterwards the situation was reversed due to water stress; (4) Plant transpiration was significantly enhanced by the application of urea or its mixture with chicken manure before anthesis stage, but significant difference was not found between these two nitrogen treatments.

Key words: ground cover rice production system; transpiration; water balance; water consumption

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Effects of rainfall and underlying surface on sediment yield in the main sediment-yielding area of the Yellow River

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Abstract: Sediment yield of the Yellow River has obviously decreased in recent years, which had become a hot topic of general interest. In this study, basin area above Tongguan station was choose as the study region which natural sediment yield accounted for about 90% of the total sediment yield in the entire Yellow River basin. The rainfall-sediment correlation models was modified with the optimized rainfall indexes and model's function type, and then sediment reduction effects of both rainfall and underlying surface factors were analyzed by using the correlation models. The results show that the sediment reduction effect of the underlying surface has been getting larger and larger since 1980, especially in recent 10 years, taking the rainfall-sediment correlation of each branches during 1956 to 1975 as a benchmark. In recent 10 years, the rainfall was generally more plentiful than the average value of it in 1956-2014, and so the rainfall factor was not the reason of the sediment yield reduction of the Yellow River. The total sediment reductions due to the change of the underlying surface in 2005-2014 and 2010-2014 were separately 1387~1545 million t/a and 1570~1870million t/a.

Key words: Yellow River; main sediment-yielding area; precipitation; land surface; sediment reductions

PDS/GP model with variable parameters and its application for flood frequency analysis

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Abstract: Flood frequency analysis is traditionally based on the assumption that the region is homogenous and the parameters are constant. Taking parameters of generalized Pareto distribution (GP) as random variables, the PDS/GP model which can reflect the spatial and temporal heterogeneity of hydrological series is constructed in this paper. The PDS of independent samples is firstly determined by an automatic threshold selection method. Then the linear moment (LM) with covariate is derived and the estimators are given by kernel regression technology. The case study in Danjiangkou Reservoir shows that the estimation intervals of scale parameter and design floods include those values calculated by the static model. It is obvious that the PDS/GP model with variable parameters does well in uncertainty analysis of random variable on prediction. Furthermore, it indicates that the estimation interval range becomes larger as the return period increases, which reflects the uncertainty of extrapolation of the frequency distribution. And it is necessary to consider the spatial and temporal heterogeneity of hydrological series in Danjiangkou Reservoir.

Key words: PDS/GP model with variable parameters; automatic threshold selection; linear moment with covariate; kernel regression; flood frequency analysis; Danjiangkou Reservoir

Prediction method for erosion and deposition on typical sandy bed sections of the Yellow River and its applications

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Abstract: To reverse the unbalance of water and sediment in the Ningxia-Inner Mongolia reach of the Yellow River, a method was proposed to predict the volume of silting sediment according to various observed sediment load and discharge data from some typical sandy bed sections. The method is able to optimize the allocation of water requirement for sediment transport and to improve its sediment transporting capacity based on the principle of river dynamics. The measured test data shows that the method can assess easily and quickly the sediment factors with the runoff flow, thus giving a better estimation of the silting sediment volume in the reaches downstream. Analysis of the predicted volumes of silting sediment under different conditions has shown that the section starting from Inner Mongolia Bayangaole to Toudaoguai possessed the highest efficiency of riverbed scour with a speed of 1500m^3/s under the current situation, thus recommends the approach of low flow multi-stage flush to reshape the river channel in the initial adjustment. In addition, according to the amount of quickly estimated sediment under different import conditions, such method can provide technical support for the process control of the river sand and river channel regulation planning.

Key words: sandy river; sand carrying capacity; erosion and sedimentation; river sediment control

Rate dependence of concrete double-K fracture toughnesses

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Abstract: This paper presents a study on the effects of loading rate on double-K fracture toughness using central-notched split-tension cube geometry. Fracture tests were carried out under four different strain loading rates varying from 10^{-5}/s to 10^{-2}/s. The results show that double-K fracture calculation theory, developed previously for quasi-static strain loading rate, can be further extended to seismic loading rate. It was also shown that, as strain loading rate increases, the initiation fracture toughness lineally increases but the unstable fracture toughness first increases then maintains a nearly invariant trend. In the case of strain loading rate no more than 10^{-3}/s, specimens with higher strain loading rate presented a bigger critical crack propagation Δa_c and slower critical crack propagation rate. However, in the case of strain loading rate greater than 10^{-3}/s, critical crack propagation Δa_c reduced for specimens with higher strain loading rate and critical crack propagation rate sharply increased. Subsequently, two models to predict the influence of the loading rates on the initiation fracture toughness and unstable fracture toughness were proposed by introducing the nominal cracking strength rate and critical crack propagation rate, respecitively.

Key words: strain loading rate; central-notched split-tension cube specimens; concrete; double-K fracture toughness; critical crack propagation rate

Effect of fracture toughness and tensile strength on fracture based on boundary effect theory

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Abstract: Based on the Boundary Effect Theory, the effect of fracture toughness and tensile strength on fracture of material and structure were studied. The equivalent crack a_e is introduced in Boundary Effect Model (BEM), by which two separate boundary measurements are effectively combined into a single and unified boundary measurement. Based on the ratio of equivalent crack to characteristic crack a_e/a^*_∞, the fracture control mode such as strength criteria, fracture criteria and quasi-brittle fracture, can be determined. BEM can be applied in LEFM and elastic-plastic fracture analysis, and the limit scope of application of ASTM standard and RILEM standard has been solved by BEM. Given that ASTM strict limitations to determine fracture toughness such as initial crack length and specimen size and others, a method for determining fracture toughness and tensile strength according to small specimen of RILEM was proposed. The reasonability and applicability of the proposed method has been confirmed by test results analysis.

Key words: boundary effect; fracture toughness; tensile strength; ASTM; RILEM

Effect of undisturbed Q_3 loess's microstructure on its SWCC

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Abstract: In order to explore the relationship between the soil water characteristic curves (SWCC) of undisturbed loess with its microstructure, basic mechanical parameters of undisturbed Q_3 loess at the same location but different buried depth were measured firstly and then the corresponding SWCCs by the TEN tensionmeter. The measured SWCC was modeled by the Fredlund & Xing model. Afterwards the microstructures of undisturbed Q_3 loess at different buried depths were obtained by the optical microstructure and the Photoshop Synthesis Technology. The pore size distribution characteristic was quantitatively analyzed to obtain the pore size cumulative distribution and pore size distribution curves. The results show that the soil particles of the intact Q_3 loess at different buried depth are the same; for the SWCCs, in the saturated zone, the bigger the buried depth is, the lower the volumetric water content is at the same suction value, while the relationship in the transitional zone is contrary to the saturated zone; at the residual zone, the SWCCs of intact Q_3 loess converges together. This discrepancy is mainly controlled by the different pore size distributions. Then a model based on the pore size distribution curves was established to predict the SWCC and the predicting values are close to the measured ones.

Key words: loess; SWCC; microstructure; pore size distribution

Design of regulation line based on check and balance mechanism

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Abstract: Design of regulation line is an important content in river regulation. Only the ranges of design parameters are given in the latest code for design of river regulation, which have to be determined by experiences in the design. Based on the study of the water and sediment transport capacity and the flow guiding capacity of the river bend, the check and balance mechanism is suggested in design of regulation line. As an example, the regulation lines of Daliusi-Laojunmiao reach of the Yellow River are designed by this method. The design method is feasible by comparing with the actual river morphology. At last, the regulation lines between Pifanggedan and Baiyinchilao reach of the Yellow River are designed by this method.

Key words: regulation line; the radius of curvature; the straight section length; check and balance mechanism

Experimental research and numerical simulation on gas-liquid two-phase flow of bubble velocity distribution in aeration tank

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Abstract: The gas-liquid two-phase flow widely exists all over the industry sectors, such as hydraulic and wastewater treatment projects. The flow patterns and velocity field distributions can directly affect the operation devices performance, which are studied in this article employing the numerical simulation along with experimental research. A PIV experimental study of gas-liquid two-phase flow has been carried on a cylindrical experimental device, and the gas velocity vector fields are obtained accurately by image processing and particle image velocimetry technology. After considering the situations of turbulence and interphase forces, by using the Euler-Euler two-fluid model and bubble population balance model (BPBM), numerical simulations of two-phase flow are performed and compared with experiment results, the error of mathematical models is about 10%. The research result shows that the proposed model and calculation method can achieve accurate result of flowing regularity and velocity distributions in gas-liquid two-phase flow.

Keyw ord: gas-liquid two-phase flow; particle image velocimetry; bubble population balance model; velocity distribution

Optimal operation scheduling of an adjustable-blade pumping station in the East Route of South-to-North Water Diversion Project

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Abstract: The South-to-North Water Diversion Project aims to solve the lack of water resource problem in northern China. The fourth HuaiAn pumping station is one of the pumping stations in the East Route Project. On account of basis of the time-of-use electricity tariff, the operation optimization has been studied to set up the mathematic model of adjustable-blade with the minimum cost in the pumping station unit. Based on the analysis of the characteristics of this model, it has also put forward an improved dynamic programming algorithm. Finally, the paper utilises case to justify the feasibility of the algorithm. The results show that: (1)compared with the designed setting angle, the adjustable-blade scheme can save energy cost of the pumping station by 4.88% under the circumstance of designed pumping head and full load; and (2)energy cost efficiency of pumping station is influenced by two key factors, blade angle and flow shift. The former one is related to the characteristic curve of pumps: the larger the pumping head is, the less influence of blade angle will be. The latter one is subjected to the capacity and demand: the higher the capacity is, the more apparently load transfers. When the demand is lower, blade angle is the major factor. When demand is higher, flow shift is the major factor.

Key words: South-to-North Water Diversion Project; operation optimization; dynamic programming; energy cost efficiency

The research on bearing capacity of umbrella suction anchor foundation for offshore wind power

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Abstract: As the disadvantages in using of foundation for offshore wind power were met, a new type Umbrella Suction Anchor Foundation(USAF) was presented. Considering its features under loads, the bearing capacity of USAF under vertical load, bending moment load and combined loads were studied using finite element software ABAQUS in this paper. The displacement was conducted as failure criterion, and the displacement loading method and fixed displacement ratio procedure were respectively used for monotonic loading and combined loading. The results show that to a certain extent anchor branches and skirt of USAF can increase its bearing capacity, and it has a more obviously improve with skirt. Besides, USAF has the properties of rigid short pile and it can rotate around one point of pile. As a result, the failure envelope of USAF and which law varied with draw ratio of pile was obtained. A serious conclusions conducted from numeric calculation can provide a reference for the generalization and apply of USAF.

Key words: Umbrella Suction Anchor Foundation; bending moment load; vertical load; failure envelope; ABAQUS