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EDITORIAL BOARD

Collapse characteristics of the cavitation bubble near free surface

ZHANG Yalei, XU Weilin, ZHANG Qi, ZHAI Yanwei

(*State Key Laboratory of Hydraulics and Mountain River Engineering, Sichuan University, Chengdu* 610065, *China*)

Abstract: Study of collapse characteristics of the cavitation bubble near free surface has important significance in knowing cavitation erosion mechanism in water conservancy and hydropower project. To further understanding collapse characteristics of the cavitation bubble near free surface, experiments the spark-induced cavitation bubbles were carried out and the results show that: (1) Cavitation bubbles near free surface always deviate from the free surface when collapsing, the critical condition of deviating from the free surface is that the distance between the cavitation bubble and the free surface is about five times of the maximum radius of the cavitation bubble. The larger the size of the cavitation bubble or the closer the cavitation bubble away from the free surface, the more obvious the phenomenon will be. (2) Double cavitation bubbles near free surface collapse towards each other and fuse together and the fusion body deviates from the free surface. (3) Under the influence of the free surface and the air bubble, the direction of collapse of the cavitation bubble is vector sum of the respective effect of the free surface and the air bubble. A quantitative knowledge of cavitation bubbles near free surface was developed in this study and collapse directions of cavitation bubbles could be predicted under certain conditions.

Keywords: cavitation bubble; free surface; air bubble; collapse characteristics; direction of collapse

Study on dimension reduction for optimal operation of large-scale hydropower system I. Theoretical analysis

FENG Zhongkai, NIU Wenjing, CHENG Chuntian, SHEN Jianjian, WU Xinyu
(*Dalian University of Technology, Institute of Hydropower System and Hydroinformatics, Dalian* 116023, *China*)

Abstract: With the continuous expansion of hydropower system in China, the existing theories and methods are limited by the severe curse of dimensionality or premature convergence arising from the large computing scale, which has been a shackle for the optimal operation of hydropower system. There is an urgent need to analyze the bottleneck of existing methods, providing new ideas to develop new methods effectively that balances solution efficiency and calculation accuracy. Therefore, the time-space complexity of various methods for the optimal operation of hydropower system is analyzed. Secondly, "four-in-one dimensionality reduction" is proposed and this paper suggests that research should be carried out in space dimension, time dimension, state dimension and combination dimension to realize the dimensionality reduction, which would be a good reference value for large-scale hydropower development.
Keywords: hydropower system; optimal operation; dimensionality reduction; complexity; enumeration method; linear programming; dynamic programming; intelligent algorithm

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Research on multi-objective operation based on improved NSGA-Ⅱ for the lower Yellow River

WANG Xuebin, CHANG Jianxia, MENG Xuejiao, WANG Yimin
(*State Key Laboratory Base of Eco-hydraulic in Arid Area, Xi'an University of Technology, Xi'an* 710048, *China*)

Abstract: The relationship of beneficial goals, flood control and ecological goals is neither fully coordinating nor completely opposite, which is the physical basis of multi-objective coordination of reservoir operation. In this paper, an integrated operation model considering ecological and beneficial goals is constructed based on the contradiction and unity between different objectives of reservoir operation. In addition, an improved Non-dominated Sorting Genetic Algorithm-Ⅱ method with Individual Constraints and Group Constraints (ICGC-NSGA-Ⅱ) is proposed to solve the model. By taking the cascade reservoirs, Xiaolangdi and Xixiayuan reservoir in the lower Yellow River as case study, a multi-objective operation model solved by ICGC-NSGA-Ⅱ method is built, which is designed to explore the relationship of the water supply, power generation and ecological benefits. The results show that the ICGC-NSGA-Ⅱ method can obtain a set of dispatching schemes which reflects the non-dominated relationships among the multi-objectives in a relatively short time. Moreover, it is found that the asymmetric trade-offs between the benefits of ecology, water supply and power generation really exists. In general, with the increase of power generation, the guarantee rate of ecological and comprehensive water supply decreases. The power generation competes with ecological water shortage stronger than with comprehensive water shortage. The study can provide technical support and reference value to multi-objective operation in of the lower Yellow River in the future.
Keywords: reservoir operation; multi-objective decision; individual constraints; group constraints; NSGA-Ⅱ

Estimation of phosphorus transport in rivers with parameters updating based on data assimilation

XU Xingya[1], FANG Hongwei[1], HUANG Lei[1], LAI Ruixun[2], LIU Xiaobo[3]

(1. *State Key Laboratory of Hydroscience and Engineering, Tsinghua University, Beijing* 100084, *China*;
2. *Yellow River Institute of Hydraulic Research, Zhengzhou* 450003, *China*;
3. *Department of Water Environment, China Institute of Water Resources and Hydropower Research, Beijing* 100038, *China*)

Abstract: It is of great importance to enhance the numerical phosphorus transport models to estimate the temporal and spatial distribution of phosphorus in rivers in order to prevent and control eutrophication and algal blooms in water environment. Data assimilation is a new technology to combine the numerical modelling with observation, which is able to improve the accuracy of model output by incorporating the observations into numerical model to update the model states and correct the model parameters. In this study, Particle Filter (PF), a sequential Monte Carlo data assimilation algorithm, is employed to combine the numerical hydrodynamic-sediment-phosphorus model with phosphorus observations to develop a data assimilation system to improve the estimation of phosphorus concentration in rivers. When the phosphorus observation becomes available, the model state variable, phosphorus concentration, will be updated and the model parameter, partition coefficient K_d, will be corrected according to the PF theory. The developed data assimilation system is applied to the Changjiang River segment from Cuntan to Three Gorges Dam to evaluate its performance of estimating phosphorus transport in a real event. The results show that the developed data assimilation system can update phosphorus concentrations and correct K_d effectively and dynamically at the assimilation time. After assimilation, the accuracy of estimation of phosphorus transport can be enhanced significantly due to the effect of assimilation, indicating the developed data assimilation system has a good performance in the real event.

Keywords: river sediment; phosphorus transport; particle filter; data assimilation; Internet of things

Study of vertical velocity distribution in debris flow based on solid-liquid two-phase flow model

LE Maohua[1, 2], HAN Qiwei[1, 2], FANG Chunming[1, 2]

(1. *China Institute of Water Resources and Hydropower Research Department of Sediment Research, Beijing* 100048, *China*;
2. *State Key Laboratory of Simulation and Regulation of Water Cycle in River Basin, Beijing* 100038, *China*)

Abstract: The vertical velocity distribution of debris flow is one of the key parts of its kinematics. Based on the solid-liquid two-phase flow model, the constitutive relation of debris flow with equal or unequal two-phase velocity was analyzed, and the calculation methods for the vertical velocity distribution were studied. Under the assumption of two-dimensional steady uniform flow, the vertical velocity distribution formula of the solid and liquid phases was deduced in the laminar and turbulent flow regime, and the experimental data of the unsaturated stony debris flow was used to verify the formula. The result indicates that the two phase velocity difference is the nature of the characteristic of the interaction between the solid and liquid phases, and the solid-volume fraction which plays an important role in the vertical velocity distribution calculation is associated with the modular parameters in the constitutive equations. The solid-liquid model-based vertical velocity distribution formula has a more general meaning than the existing formulas, and the calculated value of the formula agrees well with the experimental data.

Keywords: debris flow; vertical velocity distribution; solid-liquid two-phase flow

Experimental and numerical comprehensive analysis on overall stability of Jinping I high arch dam

YANG Baoquan[1, 2], ZHANG Lin[1], CHEN Yuan[1], CHEN Jianye[1], DONG Jianhua[1]

(1. *State Key Laboratory of Hydraulics and Mountain River Engineering, College of Water Resource & Hydropower, Sichuan University, Chengdu* 610065, *China*;
2. *Nottingham Centre for Geomechanics, Faculty of Engineering, The University of Nottingham, Nottingham* NG7 2RD, *UK*)

Abstract: The overall stability of the high arch dam is one of the key issues in construction of the project. Geo-mechanical model test and numerical calculation are the main methods to study this issue. Jinping I high arch dam is featured with complicated geologic structures of various types of faults, dykes, joints and fissures, and its overall stability is greatly influenced by these structures. It has great dam height and huge capacity of the reservoir, and the reinforcement was difficult. In this paper, firstly, the evaluation basis for the safety factor of dam stability is established based on the comprehensive method. Than adopted the methods of 3D geo-mechanical model test and 3D nonlinear FEM calculation to study the overall stability of Jinping I high arch dam under the condition of reinforced foundation. The workability of the arch dam under normal conditions, and the deformation characteristics, failure patterns and mechanisms of the dam abutment and foundation are obtained. The analysis shows that the overall stability of safety coefficient is 5.2~6.0 by comprehensive model test and 5.98 by comprehensive FEM computation. The overall stability of Jinping I high arch dam is evaluated synthetically by combining the results of the two methods. The research results provide an important scientific basis for monitoring and safe operation of the project. It also can provide a reference for the stability analysis of other high arch dams.

Keywords: high arch dam project; overall stability; physical simulation; numerical calculation; comprehensive analysis

Study on hydraulic characteristics of end-dumping closure-gap in curve river

XIONG Yi[1, 2], HU Zhigen[1], LU He[1], WANG Qin[3], WANG Qiang[3]

(1. *School of Water Resources and Hydropower Engineering, Wuhan University, Wuhan* 430072, *China*;
2. *Central and Southern China Municipal Engineering Design & Research Institute Co., Ltd. Wuhan* 430010, *China*;
3. *Hydrochina Huadong Engineering Corporation, Hangzhou* 310014, *China*)

Abstract: The water flow characteristics during the closure of curve river is extremely complex: both the curve shape of river and the layout of closure structures take great influences on the difficulty of river closure. The study of the hydrodynamic characteristics in different layout modes will be useful in determining the appropriate plan for river closure. The main influencing factors for curve river closure were analyzed, and a calculation model for the flow regime of gap was built on the basis of construction hydraulics. The influences of the width ratio of gap to river, the bend angle and the gap location on flow velocity were studied. The differences of time-varying and place-varying for flow velocity in gap were put forward, and relative water depth and flow velocity of gap with respect to the river bend were given by this model. Finally, the feasibility of the calculation model and the applicability of the conclusions had been verified by the curve river closure of Danba Hydropower Station construction. The study can be an important reference for the optimal design of river closure layout and scheme.

Keywords: curve river; end-dumping closure; hydraulic characteristics; construction hydraulics; curve shape

Water content in concrete under water pressure environment and the effect on its mechanical properties

WANG Qianfeng[1,2], LIU Yunhe[1], PENG Gang[2]

(1. *Scholl of Civil Engineering and Architecture, Xi'an University of Technology, Xi'an* 710048, *China*;
2. *College of Civil Engineering & Architecture, China Three Gorges University, Yichang* 443002, *China*)

Abstract: This paper presents a study on the water content characteristic and the influence of pore water on mechanical properties when concrete under water pressure environment. The test was carried out to obtain curves of water content for concrete under different water pressure, and influence of water pressure variation on water content and distribution of pore water was discussed based on the mesoscopical pipe-pore network model. Furthermore, mechanism for effect of water content and scale of pore water on the static and dynamic mechanical properties of concrete was analyzed. The results show that water content of concrete increases with increasing water pressure, while water pressure exceeds a certain value, the increase of water content is insignificant; under high water pressure, the pore space in concrete is less for water to flow and a portion of pore water is on smaller scale, which resulting in greater viscous stress and excess pore water pressure when concrete under the dynamic loading, and these can lead to the nonlinear increase for the strength of concrete as strain rate rises. However, the strength of concrete is not affected by water pressure. In conclusion, the mechanical properties of concrete are not only related with water content and loading rate, and but also closely related to the scale of pore water.

Keywords: concrete; water pressure environment; water content; pore model; mechanical properties

Influence of drying stress history on the mechanical behaviors of silty clay under saturated condition

LIU Wenhua[1, 2], YANG Qing[2], SUN Xiuli[1], HUA Yuan[1]

(1. *School of Environment and Civil Engineering, Jiangnan University, Wuxi* 214122, *China*;
2. *State Key Laboratory of Coastal and Offshore Engineering, Dalian University of Technology, Dalian* 116024, *China*)

Abstract: A series of consolidated undrained triaxial tests were performed to measure variations of mechanical behaviors of silt clay from Dalian, China during drying/wetting process. These tests were conducted under the saturated condition after the specimens were subjected to different drying stress histories. By contrastively analyzing the stress-strain relationship, pore-water pressure, and effective stress path of different cases, the influence of drying stress history on the mechanical behaviors of silty clay under saturated condition was studied. The test results show that the influence of drying/wetting on mechanical behaviours of silty clay under saturated condition relates to the drying stress, and the mechanical behaviours are varied more significant with higher drying stress. At the same confining pressure, the shear stiffness of the specimens subjected to drying/wetting cycle are higher than that of the initial specimens during the initial stage of shearing. The higher drying stress that specimens experienced, the higher initial shear stiffness produced. With the increase of the drying stress, the stress-strain relationship curves of silty clay alter from strain hardening to strain softening, and the development of pore water pressure converts from increase following by decrease to continue growing. The effective stress path of the initial specimens is similar to a shape of "S", whereas, the effective stress path of the specimens experienced high drying stress turns to develop towards the lower left side. Irreversible compression of soil skeleton and the micro-cracks develop during drying/wetting process, impacting the mechanical behaviors of silty clay under saturated condition.

Keywords: drying/wetting; drying stress; shear strength; stress path

Study on pores customized design in RCC in extremely cold and high altitude area

YANG Huamei[1, 2], HE Zhen[1]

(1. *The State Key Laboratory of Water Resources and Hydropower Engineering, Wuhan University, Wuhan* 430072, *China*;
2. *The State Key Laboratory of Refractories and Metallurgy, Wuhan University of Science and Technology, Wuhan* 430081, *China*)

Abstract: The high adsorption of unburned carbon in fly ash to polar material such as air-entraining admixture (AEA) could interfere the formation of air structure and its stability. In addition, the impact of environmental pressure on air entrainment also results in reduction in the air content of concrete. Therefore, it is rather difficult to entrain air voids into high-volume fly ash roller compacted concrete especially in the extremely cold and high altitude areas. This paper presents a study on the development of a new type of modified absorbent polymer (MAP) to totally replace conventional air-entraining agent as anti-freezing agent for RCC. Based on MAP features, the method to design and customize the pores system matching up RCC freeze-thaw property was proposed. Comparative studies of influence of various air entrained materials including MAP and AEA on performances of RCC were also carried out. When the MAP content and particle size were appropriate, an effectiveness pores system was formed, contributing to significantly improve freeze-thaw resistance with great increase in strength. Finally, to controllably design the pores radium and content created by MAPs in RCC was realized.

Keywords: extremely cold and high altitude; roller compacted concrete; modified absorbent polymer; pore customization; freeze-thaw resistance

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Study on calculation starting point of autogenous volume deformation based on thermal stress test

ZHU Xiaoliang[1, 2, 3], DING Jiantong[2, 3], CAI Yuebo[2, 3], BAI Yin[2, 3]

(1. *Research Center on Hydraulic Structures, Jiangxi Hydraulic Research Institute, Nanchang* 330029, *China*;
2. *Material Structure Engineering Department, Nanjing Hydraulic Research Institute, Nanjing* 210029, *China*;
3. *Research Center on New Materials in Hydraulic Structures, Ministry of Water Resources, Nanjing* 210029, *China*)

Abstract: For the starting point problem existed in calculating autogenous volume deformation by the standard test methods, ASTM C1074 test method for activation energy has been improved, taking the expansive abrasion-resistant concrete as the research object. More accurate activation energy of cementitious materials is obtained, and equivalent age of the specimen can be calculated under the actual temperature conditions based on the activation energy. Using the advantageous characters of thermal stress test and taking the equivalent age corresponding to the first zero stress as the effective starting point, an improved autogenous volume deformation model has been established on the basis of the model put forward by Japan Concrete Institute Conference. The improved model takes the maximum expansion value of autogenous volume deformation as a cutoff point and can simulate the deformation before and after the point separately, which provides reference for setting up a more accurate anti-crack model.

Keywords: autogenous volume deformation; calculation starting point; thermal stress test; equivalent age; abrasion-resistant concrete

Research on wear properties assessment of tubular turbine guide bearing based on H-K Clustering-Logistic Regression Model

DANG Jian[1,2], JIA Rong[1,2], LUO Xingqi[1,2], WU Hua[1,2]

(1. *State Key Laboratory Base of Eco-hydraulic Engineering in Arid Area, Xi'an University of Technology, Xi'an* 710048, *China*;
2. *College of Water Resources and Hydroelectric Engineering, Xi'an University of Technology, Xi'an* 710048, *China*;)

Abstract: The performance of turbine guide bearing has a great influence on vibration characteristics and stability of tubular turbine, thus a H-K clustering-logistic regression model is proposed in this paper to evaluate the turbine guide bearing wear property. Taking amplitudes of vibration and throw and working parameters of 3# unit in the HeKou hydropower station as independent variables, and the operating condition of turbine guide bearing as dependent variable. In order to enhance model generalization, the method of H-K clustering is introduced to discretize variables, then the wear properties assessment of tubular turbine guide bearing is realized based on logistic regression model between independent and dependent variables. The research results show that: the throw and vibration amplitudes of tubular turbine shaft system have a better explanation to the performance variation of turbine guide bearing. In addition, according to frequency spectrum analysis of characteristic signals, it can be inferred that the main reasons for turbine guide bearing wear property degradation are axis deviation and unbalanced electromagnetic tension of tubular turbine.

Keywords: tubular turbine; turbine guide bearing wear; hierarchical K-means clustering; logistic regression model; principal components analysis

Investigation on small fluctuation in governor turbine hydraulic system under interconnected operation

YU Xiaodong, ZHANG Jian, LIU Jiachun

(*College of Water Conservancy and Hydropower Engineering, Hohai University, Nanjing* 210098, *China*)

Abstract: The equivalent mechanical starting time of the interconnected system, the variation of the total output and the mathematical model of the unit under interconnected operation are presented in this paper. According to the parameters of the governor-turbine-hydraulic (GTH) system of two practical hydropower stations, the theoretical model for analyzing the stability of the GTH system and the numerical model for simulating the small fluctuation of the GTH system under small load disturbance are established respectively. The stable region of the GTH system under interconnected operation is given by using theoretical analysis. The small fluctuation process during the load disturbance is simulated with numerical model and the results are compared with those under isolated operation as well. The results show that the system is much more stable under interconnected operating condition because the unit's regulating mode is changed. Instead of keeping the unit's output constant under isolated condition, it is stable when the total output of the interconnected system is balanced to the total load demand. When the GTH system is operating under interconnected condition, the parameters of the governor should be selected with small value, which can accelerate the regulating process and improve the regulating quality.

Keywords: Hydropower station; governor turbine hydraulic system; small fluctuation; stability; interconnected operation

Scaled boundary finite element analysis for problems with discontinuously loaded side faces

PANG Lin[1, 2], LIN Gao[1, 2], LI Jianbo[1, 2], XUE BingHan[1, 2]

(1. *Institute of Earthquake Engineering, Faculty of Infrastructure Engineering, Dalian University of Technology, Dalian* 116024, *China*;

2. *State Key Laboratory of Coastal and Offshore Engineering, Dalian University of Technology, Dalian* 116024, *China*)

Abstract: The scaled boundary finite element method (SBFEM) is a semi-analytical numerical technique. It's dimensionality number can be reduced by one similar to the boundary element method of the problem. Since the side-faces passing through the scaling center are not discretized in SBFEM, the load acting on the side-faces is approximated as varying as a power function of the radical coordinate in practical application. However, when the assigned distribution of the load is not continuous, some complex treatment, such as introducing superfluous polygon elements near the point of discontinuity, is needed. A simple and effective approach is presented to deal with such situation. Thus, when the load distributed on the side-faces changes, it's unnecessary to adjust meshes, which simplifies the computation and extends the application range of the SBFEM. Numerical examples validate the effectiveness of the proposed approach.

Keywords: scaled boundary finite element method; discontinuous loads; side-faces; crack surface tractions; fracture mechanics