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EDITORIAL BOARD

A coupling model of load adjustment for cascade hydropower stations based on inflow uncertainty: A case study of Jinping-guandi cascade hydropower stations

JI Changming[1], LI Rongbo[1], TIAN Kaihua[2], ZHANG Yanke[1], LI Chuangang[1]

(1. *School of Renewable Energy, North China Electric Power University, Beijing* 102206, *China*;
2. *Yalong River Hydropower Development Company Ltd., Chengdu* 610051, *China*)

Abstract: To solve the deviation caused by inflow uncertainty between the actual operation requirements of cascade hydropower stations and its original power generation schedule, on the one hand, an early warning mechanism for safe operation, which combines risk management connotation and hydropower stations operation rules, is proposed to meet the goal of establishing continuous monitoring and evaluation on the schedule. On the other hand, a new coupling model of load adjustment for cascade hydropower stations is developed based on error analysis method and reservoir operation theory. By setting the early warning results as time control nodes, a nested application mode for the mechanism and the model is constructed. Meanwhile, an algorithm considering security constraints in the power grid is introduced herein. Consider Jinping-guandi cascade hydropower stations as an example. The modeling results show that the proposed model can effectively solve the problem that the power plant is forced to reduce output or release surplus water due to inflow uncertainty. The developed load adjustment scheme can also meet the requirements of hydropower stations operation and ensure safety and stability of power grids. Hence, the rationality of the model is verified by the modeling results.

Keywords: cascade hydropower stations; inflow uncertainty; early warning mechanism; load adjustment; coupling model; Jinping-guandi cascade hydropower stations

Investigation of the fiber effect on the permeability of cracked concrete

DING Yining[1], REN Xianwei[1], LI Dong[1]

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

Abstract: According to the splitting testing, controllable cracks are brought into the specimen for studying effects of fibers on permeability of cracked concrete. Crack patterns are analyzed by Supereyes digital microscope and IPP software. To study the permeability of cracked specimens, the water permeability experiment is implemented under a varied water head as well as a constant water head. According to the Darcy's law and Parallel plate theory, the correcting permeability of fiber reinforced concrete with a single crack is suggested. Research shows that: as to the splitting test, the failure form of plain concrete is brittle and can't control the speed of crack's development. After adding some of structural steel fibers, the specimen shows a better toughness and deformation capacity, and that the cracking development can be controlled easily. Structural steel fibers can improve the crack tortuosity, reduce the correcting factor and weaken the penetration ability of permeable medium. Compared with the traditional permeability coefficient, the correcting permeability of concrete with a single crack can sensitively reflect the influence of inner crack pattern under a constant water head, and can also analyze the relationship of them quantitatively.

Keywords: permeability; crack pattern; fiber reinforced concrete; correcting coefficient

Control criterion of water inrush for drainage hole in the base of Xiangjiaba Gravity Dam

FENG Shurong[1], JIANG Zhongming[2], ZHONG Huiya[1], ZENG Xiangxi[1],
LI Xuezheng[1], DING Peng[2]

(1. *PowerChina Zhongnan Engineering Corporation Limited*, *Changsha* 410014, *China*;
2. *School of Hydraulic Engineering*, *Changsha University of Science &technology*, *Changsha* 410114, *China*)

Abstract: To monitor the safety related to seepage of the dam foundation, a real-time automatic control system was employed for adjustment of uplift pressure and water inrush in the dam base of Xiangjiaba hydro-power engineering. The controlling criterion of water inrush of the drainage hole is one of the most important indices for the operation of the system. Based on the analysis of the measured data of dam foundation seepage status, numerical method of seepage analysis was employed for the research of distribution of the uplift pressure and hydraulic gradient in the foundation of NO.3 dam section. Relationship between water intrusion and water pressure at the outlet of the drainage hole was also obtained. According to the above relationship, combination with the request of design value of uplift pressure and controlling hydraulic gradient of the dam foundation, a control criterion of discharge of drainage hole for the seepage controlling system of Xiangjiaba hydro-power engineering was proposed. The research results were applied in the operation successfully and achieved the desired purpose.

Keywords: gravity dam; seepage control system of dam foundation; water inrush of drainage hole; uplift pressure; seepage failure

Integrated utilization of the Three Gorges Cascade for navigation and power generation in flood season

ZHOU Jianhzong[1], LI Chunlong[1, 2], CHEN Fang[1], ZHANG Yongchuan[1]

(1. *School of Hydropower and Information Engineering, Huazhong University of Science and Technology, Wuhan* 430074, *China*;
2. *China Three Gorges Projects Development Company Linited, Chengdu* 610041, *China*)

Abstract: The Three Gorges Cascade undertakes the tasks of flood control, navigation and power generation, while they often conflict with each other in flood season. In order to solve the problem, this paper presents a flood control mode with water level-inflow-outflow boundary, and drafts the relationship between outflow and navigation rate for quantifying navigation benefit. On this basis, an integrated utilization model of multi-objective optimal operation in flood season is proposed. According to the priorities of different objectives, 6 schemes of integrated utilization in flood season are drafted. With design scheme and 2009 optimal scheme, these integrated schemes are applied to the simulation in historical inflows and design floods for verifying their effectiveness. The results show that the integrated scheme which considers downstream flood control, navigation, power generation in turn has better performance when compared to 2009 optimal scheme. The navigation rate is enhanced to 83.42 % from 79.08 %, the total power generation is increased to 664.42 from 644.27 billion kWh, while upstream safety and downstream safety of flood control are both ensured.

Keywords: Three Gorges Cascade; flood control safety; navigation; power generation; integrated utilization in flood season

Construction schedule risk analysis of rockfill dams based on coupling improved PERT and BBNs

ZHONG Denghua, YAN Yuliang, ZHANG Jun, WANG Fei

(*State Key Laboratory of Hydraulic Engineering Simulation and Safety, Tianjin University, Tianjin* 300072, *China*)

Abstract: Traditional project evaluation and review technique (PERT) considers the three-time estimates whose subjectivities are too strong, and doesn't consider the effect that the correlations of risk factors implementing on the project duration, influencing the objectivity of risk assessment and the reliability of analysis results. This study proposes the coupled improved PERT-Bayesian belief networks (BBNs) model. First, the reasoning function of BBNs is used to analyze the correlations among risk factors. Second, combining the method of Triangular Fuzzy Number and Fuzzy Measure to optimize PERT and introducing the risk preference index of decision makers. Then apply the model to practical engineering, obtaining the risk preference index-period-completion probability distribution curve, which can be used to provide guidance for decisions. An engineering application result shows that compared with the traditional PERT, the method obtains more reliable simulation results and provide a reliable theoretical basis for actual construction schedule designing.

Keywords: core rockfill dams; schedule risk; risk analysis model; construction simulation; risk preference index-period-completion probability distribution curve

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Evaluation method for collapsibility of channel engineering with Loess foundation based on moistening deformation

ZHANG Aijun[1], XING Yichuan[2], WANG Haitao[3], GUO Minxia[1], REN Wenyuan[1]

(1. *College of Water Resources and Agricultural Engineering, Northwest A&F University, Yangling* 712100, *China*;

2. *China Institute of Water Resources and Hydropower Research, Beijing* 100038, *China*;

3. *Engineering Quality Inspection Ccentre, Administration of Xinjiang Ili River Basin Development and Construction, Ili* 835000, *China*)

Abstract: Collapsible deformation is a common problem for projects such as channel engineering in Loess regions. In China, the current practice of "Code for building construction in collapsible loess zone" (GB 50025-2004) has defects that not suitable for channel projects, especially on the aspects of standard for engineering classification, selection of overlying pressure and standard for collapsibility classification. Supported by a large diversion channel project (the design discharge is 215.9 m^3/s, and the depth of Loess reached 30m), this paper proposed a new evaluation method for collapsibility of channel engineering with Loess foundation based on moistening deformation, to compensate for the shortage of the existing specifications. The practical application shows that the proposed method has the advantages of complying with actual conditions of channel engineering and fully considering the effect of seepage control layer, according to the analysis of actual overlying pressure and moistening deformation.

Keywords: Channel engineering; Loess; Collapsibility; Evaluation method

Water use right trading model of irrigation area based on supply-demand relation and production function

SHAO Dongguo, WU Zhen, GU Wenquan, CHEN Shu

(*State Key Laboratory of Water Resources and Hydropower Engineering Science, Wuhan University, Wuhan* 430072, *China*)

Abstract: As market plays an increasingly important role in the allocation of resources, water right trading is imperative to optimize the allocation of water resources, improve the efficiency of water use and promote water saving, which has been an important part of the pilot construction of the most stringent water resources management system in China. In this paper, water resources system analysis and economic theory are used and water use right trading model of irrigation area is established on the base of supply-demand relation and the production function. In the model, the maximized transaction income of transactors is taken as the goal and the value of the respective water is determined by C-D production function and the supply-demand relation, and Nash equilibrium price and water quantity are bound to determine the transaction volume and transaction income. This model is applied to water use right trading between Gaoguan reservoir irrigation area and Yingcheng city in Hubei province. The results show that with the depth of water saving in Gaoguan reservoir irrigation area, transaction volume is maximal under 50% conditions of current year 2013, planning year 2020 and 2030, which are 37.447 million cubic metres, 47.44 million cubic metres, 58.29 million cubic metres, respectively; trading amount of dry year of 75% and 85% are reduced among 12.25 million cubic metres to 41.81 million cubic metres, and 2.14 million cubic metres to 15.70 million cubic metres, respectively; conditions of water use right trading are lacked in special drought year of 90%. Water use right trading can not only ease the level of water shortage significantly under 50% conditions of current year 2013, planning year 2020 and 2030 in Yingcheng city and make water shortage rate decreased, but also improve net benefit of Gaoguan reservoir irrigation area by 2.02 million yuan to 705.42 million yuan and improve net benefit of Yingcheng city by 0.88 million yuan to1.32 billion yuan; but to fully solve the problem of water supply in Yingcheng city for drought year, it is necessary to establish water saving capacity trading income compensation investment mechanism of water saving in irrigation district, mobilize the enthusiasm of water conservation and fully tap the local water saving potential. It is of great significance to establish and improve the water right trading mechanism and the most stringent water management system, improve the utilization efficiency of water resources, guide water saving society construction in China, ensure the safety of urban and rural water supply.

Keywords: irrigation area; water use right; transaction model; production function; supply and demand relations

Study on the polyurea-coat debonding failure of impervious structurein contractionjoints

LI Bingqi[1], ZHANG Yuchi[1], LIU Xiaonan[2], LI Zeyang[3]

(1. *China Institute of Water Resources and Hydropower Research*, *Beijing* 100038, *China*;
2. *Beijing University of Chemical Technology*, *Beijing* 100029, *China*;
3. *Mathematics*, *The University of Manchester*, *Manchester* M139PL, *United Kingdom*)

Abstract: Leakage failure of contractionjoints is extensively found in hydraulic structures and the studies on the failure mechanism are urgently needed to guarantee the regular service and maintenance of these structures.In this paper, based on the South-to-North Water Diversion Project and the damage and fracture mechanics, the finite element method with cohesive zone model(CZM)is used to analyze the failure process of polyurea-composite impervious coat in the contraction joints. According to the load-displacement deformation data obtained from impervious coat debonding experiments, the interface stiffness and viscosity coefficient for the adhesive layer cohesive elements are calibrated. In the numerical examples, we determine the critical loads of debonding of the coat and we also discuss the effect of the thickness of polyurea-composite impervious coat on debonding critical loads. Furthermore, the effects of the thickness, elasticity modulus of coat and shear stress of cohesive elements on the lengthof coat debonding when the water pressure is applied on the open contraction joint are included in our discussion as well. The numerical results show the consistency of debonding loads obtained from FEM simulation and experiments, which demonstrate the rationality of the parameters of the CZM and the validity of the mechanism of polyurea-composite impervious coat debonding failure. From the analysis results for the case that the water pressure is applied on the opened contraction joint, the proposed method for the failure analysis of the polyurea-composite impervious coatcanbe used for quantitatively reference to the impervious design of contraction joints.

Keywords: cohesivezone model; FEM; contraction joints; polyurea-composite impervious system; coat debonding; water pressure

Seismic response of a concrete-faced rockfill dam to near-fault pulse-like ground motions

ZOU Degao[1, 2], HAN Huichao[1], KONG Xianjing[1, 2], ZHOU Yang[1, 2]

(1. *State Key Laboratory of Coastal & Offshore Engineering*, *Dalian University of Technology*, *Dalian* 116024, *China*;
2. *School of Hydraulic Engineering*, *Dalian University of Technology*, *Dalian* 116024, *China*)

Abstract: An increasing number of high rockfill dams are constructed and planned in the western region, and most of them are situated near the seismic fracture belt. With the increase of high dams, the probability of encountering near-field earthquake is increased, and the seismic response of dams to near-field ground motions should be studied urgently. In this paper, ten near-fault ground motions are selected from Jiji Earthquake occurred in Taiwan, and the numerical results of the dam under two types(pulse-like and non-pule) of earthquake records are compared, including acceleration, horizontal displacement of the rockfill and lop-direction tensile stress of the concrete face slab of concrete-faced rockfill dam(CFRD). It is pointed out that horizontal displacement of the rockfill and lop-direction tensile stresses to pulse-like near-fault ground motions are significantly greater than that to non-pulse ground motions. Meanwhile, pulse-like effect grow along with the increase of *PGV*/*PGA*(peak ground velocity/peak ground acceleration). Therefore, the special research should be done on the seismic response of a concrete-faced rockfill dam to pule-like ground motions. It is necessary to evaluate comprehensively the security and ultimate aseismic capacity of rockfill dams.

Keywords: near-fault; pulse-like ground motions; concrete-faced rockfill dam; seismic response

Variability analysis of freezing depth mode of vertical buried pipes with different materials in cold area

WANG Enliang, ZHANG Anqi, BAO Tiane, LIU Xingchao

(*School of Water Conservancy and Civil Engineering, Northeast Agricultural University, Harbin* 150030, *China*)

Abstract: Denillin freezing meter was often used to monitor soil frozen depth in cold area, but manual measurement was easily influenced by the factors of weather, terrains, low temperature, human etc. Vertical buried pipes are always chosen to measure soil temperature field for confirming frozen depth indirectly. With the purpose of exploring the influence of different pipes (iron pipe, PVC pipe, PMMA pipe and PPR pipe) on measuring soil temperature and frozen depth, diversity of measurement results is analyzed. (1) Differences exist among the measured ground temperatures of the different pipes: smaller in the early freezing and thawing stage, and enhanced in the stabilization freezing stage obviously. A steady difference of soil temperature, which leads to a variability in calculating freezing-thawing depth, is found in the 40~120 cm layer. (2) The method, getting freezing front depth by interpolating -0.15°C isothermal on the freezing and thawing layer in freezing period and obtaining thawing depth through linear extending 0°C isothermal on the thawing layer in thawing period, makes the calculation thawing point more accurate and reflects the real condition of the freezing-thawing process of soil preferably in comparison with traditional interpolation. (3) There is a little difference in measuring freezing-thawing depth by using the method mentioned above. The frozen depth of PVC, PPR and PMMA(thermal insulation material) pipes are smaller than the actual condition, where the difference is remarkable. The thawing time of different pipes is 8~13 days ahead of time in comparison with the revised freezing-thawing process. The iron pipe is a better pipe which has a high precise in reflecting the freezing condition through the difference analysis, the average deviation is 7.5cm in the freezing period. (4) The Stephen empirical formula is adopted in calculating the freezing-thawing process of the test area, and the results verify the accuracy of the manual observation.

Keywords: cold area; frozen depth measurement; temperature; interpolation; variability analysis

Effects of vertical mixing on algal growth in the tributary of Three Gorges Reservoir

GAO Qifeng, HE Guojian, FANG Hongwei, HUANG Lei

(*State Key Laboratory of Hydroscience and Engineering, Tsinghua University, Beijing* 100084, *China*)

Abstract: Algal blooms that occurred frequently in the tributaries following the impoundment of the Three Gorges Reservoir has become a great challenge for ecology and environment, and aroused wide concern. However, this problem still remains unresolved. In this paper a numerical simulation using the EFDC model was conducted to simulate the three-dimensional hydrodynamics and water quality of the mainstream and Xiangxi Bay in front of the dam in 2008, and the algal blooms was investigated in terms of vertical mixing. The simulation succeeded in reproducing the thermal stratification and density currents in the Xiangxi Bay. The computed results of velocity and temperature coincide well with the field data. The results show that there are significant differences between the hydrodynamic characteristics in the Yangtze River and Xiangxi Bay, the vertical mixing intensity in main stream is much higher than that in the Xiangxi River. Besides, chlorophyll concentration shows a negative correlation with vertical turbulent diffusivity. These results could provide a foundation for the control of algal blooms with physical methods.

Keywords: Three Gorges Reservoir; numerical simulation; turbulence model; vertical mixing; chlorophyll concentration

Parallel multi-objective optimal operation of cascaded hydropower system

NIU Wenjing, FENG Zhongkai, CHENG Chuntian, WU Xinyu, SHEN Jianjian

(*Dalian University of Technology, Institute of Hydropower System and Hydroinformatics, Dalian* 116023, *China*)

Abstract: To ensure the computational efficiency and solution quality of multi-objective optimal dispatch of cascaded hydropower system, we proposed a novel method, called parallel multi-objective genetic algorithm (PMOGA), based on the Fork/Join parallel computation framework. PMOGA makes full use of the features of multi-objective genetic algorithm (MOGA). Moreover, in order to maintain the diversity and astringency, the whole individuals are distributed into a number of sub-populations, and the migration model is used to exchange information between neighboring populations. In addition, three different strategies are introduced to enhance the convergence and diversity of solutions, which are the real number encoding technique, chaos initialization strategy and Pareto dominance by constraints. The proposed method is applied to the optimal operation of the Lancang river cascade hydropower stations. The results indicate that the method can improve the accuracy of the solutions with good convergence and diversity, which is feasible to address the multi-objective optimal dispatch problem of cascaded hydropower system.

Keywords: cascaded hydropower system; optimal operation; multi-objective optimization; genetic algorithm; parallel computing; Fork/Join framework

Study on three-dimensional internal characteristics method of Suter curves for double-suction centrifugal pump

WANG Ling[1], LI Min[1], WANG Fujun[1, 2], WANG Jiabin[3], YAO Chunguang[3], YU Yongshui[3]

(1. *College of Water Resources & Civil Engineering, China Agricultural University, Beijing* 100083, *China*;
2. *Beijing Engineering Research Center of Safety and Energy Saving Technology for Water Supply Network System, Beijing* 100083, *China*;
3. *Shandong Shuanglun Co., Ltd., Shandong Weihai* 264203, *China*)

Abstract: The Suter curves of pump are the primary parameters for water hammer analysis in a pump station. The existing measurement method to obtain the Suter curves of double-suction centrifugal pump has the characteristics of high difficulty and cost, and the other method of indirect interpolating estimation has the low accuracy performance. In order to get the Suter curves of double-suction centrifugal pump quickly and accurately, a three-dimensional internal characteristics method is presented based on computational fluid dynamics (CFD) technology. This method includes three-dimensional modelling, setting of operation conditions, numerical simulation on flow field and transformation of results. The core of this method is that the relationship among flow discharge, speed, head and torque is calculated accurately by CFD technology in pump operation condition, turbine operation condition, reverse pump operation condition, reverse turbine operation condition and four brake operation conditions. It is indicated that average accuracy of $Wh(x)$ and $Wb(x)$ are improved by 39.2% and 26.3% respectively by means of the proposed three-dimensional internal characteristics method, compared with interpolating estimation method. Moreover, the predicted maximum pressure is reduced by 15.0%, the pipeline scope of vapour pressure occurrences is narrowed by 81.4%, the resulted maximum reverse discharge through pump is increased by 11.9%, and the maximum reverse rotating speed is decreased by 6.1%. This method could be used as a new approach to improve the accuracy of water hammer analysis in a double-suction centrifugal pump station.

Keywords: pump station; double-suction centrifugal pump; water hammer; Suter curves; three-dimensional internal characteristics method