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Mesoscale numerical simulation analysis for temperature distribution in early–age concrete

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Abstract: The mesoscale lattice network model, in which concrete is treated as three–phase composite material consisting of coarse aggregate, mortar and interfacial transition zone (ITZ) between the aggregate and the mortar matrix, is developed to analyze heat transport process in concrete. In terms of the Galerkin-method of Weighted Residuals and Finite Difference method, a heat conduction equation as well as its discrete form for the concrete ingredients, i.e. aggregate, mortar and ITZ, has been established assuming that mortar is the main heat source during the hydration process. A time–varying numerical simulation of the temperature distribution and the temperature fields affected by the aggregate pre–cooling and boundary conditions for early–age concrete is carried out by means of the mesoscale lattice network model, in which the thermal–chemical coupling mechanism has been taken into account. The results indicate that the mesoscale lattice network model can be effectively used to predict the adiabatic temperature rise within the early–age concrete.

Keywords: early–age concrete; mesoscale lattice network model; temperature field; adiabatic temperature rise; aggregate pre–cooling

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Systematic construction pattern of the sponge city

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Abstract: Sponge city is a new strategy of integrated urban water management in China. Due to differences in perception and limitations of disciplines in academy and practice circles, understanding of the connotation, implementation protocols and approaches of the sponge city are divergent, which hinders the research and implementation of the sponge city. Based on the identification of basic urban water–related problems, this study illustrated the scientific connotation of the sponge city, and proposed the protocols of sponge city construction. Through a systematic review, this study proposed three substantial contents, three diagnosis items, three basic approaches and three balance equations of the sponge city. The fundamental philosophy is matching the sky area with the ground area. A systematic formula that covers all elements and all processes of general sponge city construction is presented. This study may provide the foundation for research, planning and implementation of the sponge city.

Keywords: sponge city; urban water issue; construction pattern; urban hydrology; urbanization

Study on index system and judgment criterion of water resources carrying capacity

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Abstract: With the increasing of water consumption and drainage intensity, the quantity and quality of water resources become the main restraining factors of regional environment and socio-economic harmonious development, and the main factors influencing the water resources carrying capacity. Based on the four aspects of water resources, economy society, water ecology and water environment, this paper constructs the evaluation index system of "four levels and three levels" of water resources carrying capacity from four aspects: "quantity, quality, watershed and flow", and puts forward the evaluation standard of water resources carrying capacity based on evaluation index and metric, which provides a new method for water resources carrying capacity evaluation and state diagnosis. This paper takes Tianjin as an example to carry out the assessment and analysis of current water resources carrying capacity, studies show that under the situation of the total amount of water entry and the local water is 3.598 billion m^3 in Tianjin, the ecological and outbound water is 1.575 billion m^3, sewage first level A effluent COD water quality standard, Tianjin water capacity carrying capacity range of 16.86 ~ 17.72 million people, water quality carrying capacity range of 11.69 ~ 13.93 million people, water resources carrying capacity range of 11.69 ~ 13.93 million people, mean of 12.81 million people, Tianjin water resources carrying capacity belongs to water resources overloading area, the type is insufficient water quality carrying capacity.

Keywords: water resources carrying capacity; index system; judgment criterion; carrying capacity condition

Dimensional analysis of water temperature withdrawn and influencing factors in thermal stratified reservoir

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Abstract：Thermal stratification, as an important factor affecting the aquatic ecosystem, has becomes research hot topic gradually. Based on the analysis of some influencing factors, such as water temperature gradient, intake head and intake flow, an estimate model of water temperature withdrawn has been developed by using dimensional analysis. Besides of that, multiple regression analysis is performed by using SAS9.3, the quantitative relation between water temperature withdrawn and key factors is given, and show a good correlation with the measured data with a correlation coefficients of 0.956. The results show that water temperature gradient is the major factor affecting water temperature withdrawn, next is the intake head term, and the last is flow term. The water temperature will increase with the gradient in front of the dam increasing. The analyses also show that the bigger the temperature gradient, the more obviously the water temperature withdrawn varied. It is also indicated that the water temperature will decrease with the intake head increasing, and the decrease is much smaller than the increase. Besides of that, with the intake flow increasing, the water temperature withdrawn becomes higher. However, while the intake flow is greater than critical value, the water temperature shows a downward trend. A comparison between the predicted and the measured water temperature withdrawn is in close agreement with a correlation coefficient of 99.4%. The results show that the model may be used to determine water temperature withdrawn with an acceptable accuracy if the variables are within the following ranges.

Keywords：thermal stratification; water temperature withdrawn; influencing factor; estimate model; dimensional analysis method

Modeling dependence and correlation in hydrological calculation

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Abstract：Correlations widely exist in the hydrological phenomena. Correlation analysis is an important content of hydrological calculation. It is involved in nearly every field of hydrological calculation. It is of great help to solving the practical problems by finding a suitable correlation analysis method. Dependence and correlation modeling in hydrological calculation were reviewed thoroughly. The measurement and analysis methods of the correlation, as well as the relevant matters needing attention were summarized. The theoretical obstacles encountered in hydrological calculation of linear regression and auto regression methods were analyzed. The feasibility of using the Copula-based methods to solve the nonlinearity and non-normality of the hydrological variables was studied. When the long-term dependence of the increments of the reservoir storage was considered, the application of R/S analysis method in flood risk analysis was prospected. A new way to calculate the synthesis index for flood event using the thought of principal components analysis was proposed. Then the severity of the flood event can be ranked synthetically. The reliability of the results analyzed by the Copula function was studied. The distortion problem that may occur in the application of this method was also pointed out. Finally, the pseudo correlation problem which is often encountered in the hydrological calculation was analyzed.

Keywords：correlation; Copula function; regression; auto regression; R/S analysis; principal components analysis; pseudo correlation

Experimental research on hydraulic fracture of concrete

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Abstract: A series of wedge-splitting experiments on concrete specimens are conducted with a developed sealing device. This sealing device employs silicon plates and specially designed clamps to apply the water pressure within the crack instead of the use of adhesive. The experimental results without water pressure indicate that the sealing device has a minimal effect on the fracture parameters of concrete. According to the pressure data recorded by the pre-set transducers, the water pressure distributions along the crack under fast and slow loading are obtained. The internal water pressure consists of a constant curve and a parabolic curve when the crack length is larger than the critical crack length in both fast and slow loading conditions. The water within the crack has sufficient time to enter the crack when subjected to a slow split loading, and the water pressure during slow loading is over twice that of the fast loadings when reaching the same CMOD. The external water pressure has a great influence on the concrete crack propagation. With the increasing of the external water pressure, the critical loading decreases obviously. Moreover, the crack propagated in a tortuous shape in dry tests, while under hydraulic loading, the crack propagated in a straight manner.

Keywords: hydraulic fracture; sealing device; water pressure distribution; crack propagation; the loading rate

Simplified limited data ET_0 equation adapted for high-elevation locations in Tibet

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Abstract: The Food and Agriculture Organization of the United Nations (FAO) has recommended the Penman-Monteith (FAO56 P-M) method as a standard method for estimating reference evapotranspiration (ET_0) and for evaluating other methods. But the FAO56 P-M method requires many parameters that are not available in many developing regions of high elevation in Tibet. Meanwhile, the low pressure, strong solar radiation, intensive evaporation, and frequent heat transfer are special meteorological phenomena in high-elevation areas. Accordingly, the basic objective of this study is to develop a new equation requiring fewer parameters for simulating the ET_0 at high-elevation stations. When solar radiation, relative humidity and/or wind speed data are missing, a possible exception is the Hargreaves-Samani (HS) method which has shown reasonable ET_0 results with a global validity according to the FAO's Irrigation and Drainage Paper No. 56. Therefore, the new equation (HS-E) based on HS equation and elevation was developed using the meteorological data of nine stations in the Tibet Plateau from 1981 to 1990. Then the HS-E and HS equation, which requires less meteorological data to calculate ET_0, were evaluated as compared to the FAO56 P-M method. Results indicate that the computations of the improved HS-E model are obviously better than the HS model for the areas of higher than 2000m under the conditions of different time scale. The new mode, which enhanced the practical applications and computational accuracy of ET_0, can make up the shortage of HS model that the ET_0 would have negative values in arctic-alpine region of Tibet. Compared with the ET_0 calculated by FAO56 P-M equation, the daily ET_0 and monthly ET_0 calculated by HS-E model were analyzed. The Nash-Sutcliffe efficiency coefficient (*NSE*), root-mean-square error (*RMSE*) and Mean Relative Error(*MRE*) for the daily ET_0 calculated by HS-E model are 0.8, 0.53 mm/d and 13.80% and for the monthly ET_0 are 0.84, 11.90 mm/month and 12.50 %, respectively, which indicated that the HS-E model is high-quality and can calculate the ET_0 more exactly. Considering the error result of different time scales, the larger the time scale, the better the results can be obtained by the HS-E model. In conclusion, the HS-E model is suitable and accurate in the high-altitude district, which can be recommended as a simple method for calculating ET_0 in the area higher than 2000m.

Keywords: reference evapotranspiration; high elevation of Tibet; Hargreaves-Elevation equation; Penman-Monteith equation; Hargreaves equation

Multi-scale simulation of the local-scale complex flow processes in a large-scale groundwater system

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Abstract: It is a long lasting cost-benefit issue to accurately simulate the complex groundwater flow phenomena with small-scale properties within a large-scale aquifer. This work proposes a three-dimensional coupling scheme for groundwater flow simulation with multi-scale spatial and temporal discretization to solve the large-scale model within the entire domain and meanwhile multiple small-scale models within the user-specified sub-domains. The Darcy-based three-dimensional head interpolation scheme is utilized to deliver messages among models at different spatial scales. For each self-adaptive time-step marching of the small scale models, a second-order fitting curve is obtained to approximate the sharp boundary head change, which is caused by the large hydraulic gradient in the sub-domains. The coupling model allows multiple sub-models to be solved with resolution-free grids inside the arbitrarily shaped and partitioned boundaries, which largely reduces the computational costs and ensures the accuracy at small scale. A comparative analysis is conducted in hypothetical homogeneous aquifers to verify the computational efficiency of the coupling model within the non-match and free-resolution grids. The results of the test cases show obvious advantages against traditional groundwater model by largely cutting down the nodal points to be solved while retaining the original precision level over the sub-domains.

Keywords: regional-scale; groundwater; local-scale complex flow; multi-scale simulation; coupled model

Centrifuge modeling on dynamic response of water retaining structure by underwater explosion

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Abstract：Underwater explosion consists of two procedures，i.e. shock wave and bubble oscillation，both of which take up approximately 50 % of the explosive energy and would cause severe damage to structures. A satisfaction in similarities of both shock wave and bubble oscillation is only possible in centrifuge. Container for underwater explosion in centrifuge should be as large as possible to minimize boundary effects. Shock wave，bubble oscillation，and the induced dynamic responses of structure are recorded by water pressure sensor，high speed camera，accelerometers and strain gauges. This paper compares the difference between the shock load and dynamic responses of air blast and underwater explosion. Then，by changing the centripetal acceleration，gravity effects on the bubble impulse are investigated. The research also finds that there is linearity between the peak strain bubble oscillation and bubble impulse. Thus，the effects of gravity should be considered in the simulation of bubble pulse on structure.

Keywords：underwater explosion; shock wave; bubble oscillation; centrifuge; impulse

Studies on the decreasing rule of the anti-shearing strength along RCC joints （cracks） subjected to leaching

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Abstract：The evolution of anti-shearing strength along the joints （cracks） in roller-compacted concrete （RCC） subjected leaching is studied in this paper. The leaching process is accelerated and simulated by immersing RCC specimens in ammonium nitrate solution. The results show that the leaching process is developed perpendicularly to the cracking plane gradually. The leaching depth can be measured by phenolphthalein indicator together with electron probe line scanning. The porosity of RCC in both sides of the joints （cracks） increases and the microstructure becomes loose. The friction of RCC along the joints （cracks） as well as the cohesion force decreases with the increase of the leaching time. The evolution of the anti-shearing strength of RCC joints （cracks） surface can be fitted by Newtonian cooling law.

Keywords：roller-compacted concrete; joints; cracks; leakage and leaching; anti-shearing strength; decrease

Theoretical framework of floodwater resources utilization in a basin Ⅱ: cases study

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Abstract: To verify the rationality and universality of floodwater resources utilization pattern built in the part Ⅰ of this paper, an application case is carried out in the Nansi Lake basin. First of all, the present situation and development potential of flood resources utilization is evaluated, according to hydrologic data during 1974-2008 years, annual average actual availability is 1.467 billion cubic meters, the present potential and the theoretical potential are 288 million cubic meters and 733 million cubic meters, with the present utilization rate of 64.9 %. Secondly, based on the elements of the flood control system, the choosing process for the floodwater resources utilization patterns is discussed, and then two potential development patterns, multiple duration flood limited water levels of the Erjiba Dam and floodwater distribution among rivers by sluice gates in the west region of the Nansi Lake, are taken as reasonable. The flood limited water level during the later flood season (from August 21 to September 30) can increase from 34.20 m to 34.35m, which the utilizable capacity of the Nansi Lake increases by 89.4 million cubic meters, and the peak level of the Nansi Lake increases gently by 0.02-0.026 m. The optimized scheme for floodwater distribution among rivers in the west region of the Nansi Lake is put forward, which can increase water storage 135.8 million cubic meters on the premise of without increasing the risk of flood control dramatically. The results above show the development pattern of flood water resources utilization in a basin scale is reasonable and feasible which include potential evaluation, development patterns choose and decision making by balancing the risks and benefits.

Keywords: floodwater resources utilization; development pattern; floodwater distribution among rivers; multi period flood limited water level; Nansi lake basin

Flow passage optimization and performance study of the hydraulic ram pump

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Abstract：The hydraulic ram pump, an automatic water-pumping device without any external energy input like electricity or oil, can be widely used in mountainous and rural areas short of power. To solve the issues of unavailable flow passage analysis, long development period and poor performance encountered with traditional means, evaluation indexes, including head loss coefficients, drag coefficients, eccentric distance of pressure on the waste valve and velocity uniformity of the outlet, were proposed as well as numerical models. Numerical models were established and compared with the front-expansion and back-expansion flow passage. The head loss coefficients are 4.51 and 3.72 respectively. The drag coefficients are 4.11 and 2.23, the eccentric distances of pressure on the waste valve are 0.21mm and 2.02mm and the velocity uniformity of the outlet are 47.8% and 69.2%. The back-expansion flow passage has lower head loss coefficient and drag coefficient, larger eccentric distance of pressure and higher velocity uniformity of the outlet than those of the former one. Therefore, the back-expansion flow passage was adopted in the novel hydraulic ram pump. Through numerous experiments of variable supply and delivery heads, the formula for the delivery flow was built and the inflow required was given.

Keywords：hydraulic ram pump; flow passage; evaluation index; numerical model; model experiment

Study on the issues of beat vibration and resonance in hydraulic machinery

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Abstract: Beat vibration and resonance are common natural phenomena and they have great danger to the stable operation of turbine. But there is confusion about differences between beat vibration and resonance, and some false signals of beat vibration could not be recognized. It is necessary to study these issues and provide foundation for solving the unstable problems of turbine. The basic principle of beat vibration wave is introduced, and the frequency and amplitude of beat vibration are illustrated by analyzing several special cases. The basic features of beat vibration and resonance are analyzed as well as the differences of disturbing frequency and natural frequency. It is found that, resonance will not occur if the disturbing frequency is close to the natural frequency or if two different disturbing waves have the same frequency. Besides, unsound collected signals and high frequency carrier wave could cause false beat vibration. The method of avoiding false beat vibration by increasing collecting frequency, as well as the method of recognizing and identifying the beat vibration wave according to its natural features, are given out.

Keywords: hydraulic machinery; pressure fluctuation; beat vibration; resonance; beat frequency; disturbing frequency; natural frequency

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Three-dimensional critical state and dilatancy of granular materials based on DEM

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Abstract: As an important part of classical soil mechanics, the critical state is always regarded as a referent state in the foundation of the constitutive model of the granular materials, such as sandy soil. According to the microscopic structure of sandy soils, the state parameter was proposed to describe the internal structure of sand, and series of state-dependent dilatancy theory were established. However, owing to the limitation of the experimental condition, researches of granular materials' critical state and dilatancy are usually investigated by the conventional triaxial tests, without the consideration of the intermediate principle stress. Researches have shown that the loading path have some effects on the mechanical response of granular materials. In this paper, true triaxial tests are conducted using Discrete Element Method (DEM), the stress-strain behaviors are analyzed during the loading process, and the influence of the intermediate principle stress ratio on the critical state is shown. The critical state line is unique in the e-log p plane, irrelevant with the intermediate principal stress ratio. A three-dimensional state-dependent dilatancy equation is suggested by introducing the shape function. The relationship of the critical stress ratio and the Lode angle can be approximately described by a shape function. The numerical simulations show that the proposed three-dimensional equation can reflect the dilatancy behaviors of granular materials under complex loading paths, however it needs more verification of laboratory tests and theories.

Keywords: granular materials; true triaxial test; DEM; critical state; dilatancy; state parameter

Influence of geometrical parameters of straight guide vane on the flow field and hydraulic performance of bidirectional pump

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Abstract: Due to convenient manufacture, straight guide vane has been widely used in axial-flow impeller machinery. With the purpose of study on the flow characteristics of the straight guide vane and its design method, a high specific speed bidirectional axial flow pump was chosen as the research object. Based on all structured grid, the SST k-ω turbulence model was used to analyze the mechanism of flow loss and the influence of straight guide vane's geometric parameters on external characteristic and internal flow field. Then design method of straight guide vane was summarized. The results show that the flow separation region expands and a large-scale backflow appears when the chord length and vane number of straight guide vane increase, the reduction of axial spacing between the guide vane and blade will increase incidence angle of vane inlet, and then increase the separation strength. Therefore, the chord length and vane number should be decreased as far as possible, and the axial spacing should be increased appropriately under the condition of allowed structure strength. The results can provide some reference for the design of straight guide vane used in the machine with axial-flow blades.

Keywords: axial-flow pump; guide vane; numerical simulation; flow separation