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Investigation of density current plunging Ⅰ: Review of previous flume experiment works and theoretical analysis

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Abstract: This paper reviews previous flume experiment works and theoretical analysis of density current plunging, then explores the value of the densimetric Froude number F_p at the plunge point and the relationship of the value of F_p with the depth of the density current h_d. The paper contains two parts. Here the first part presents a review of experiments of plunge point with turbid, saline or cold water inflow. Experimental value of F_p=0.5~0.8 in reservoir backwater region, and F_p=0.1~0.3 in navigation guiding channels were obtained by many researchers. Then a summary was made for the previous theoretical analysis and the numerical analysis of turbulent flow models for plunge point prediction. Various authors investigated the parameter F_p which varies with the mixing coefficient, friction coefficient and the ratio of the density current depth h_d downstream of the plunge point to the plunge point depth h_p. Several schematic diagrams were developed, and analyses were made applying energy equation and momentum equation, and obtained some different types of F_p expressions. Some investigators used the method of turbulent models with numerical calculation to determine the value of h_p or F_p. Comparison was made with the experiment values of h_p or F_p. The previous theoretical analysis results of density current plunge point were used to compare with the writer's investigation results by theoretical analysis.

Keywords: density current; density current plunging; flume experiment; theoretical analysis

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Study on mechanism of energy spending and transition in open channel flow with suspended canopy

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Abstract: Suspended canopy in open channel would have an adverse impact on flow capacity. Based on the previous theory of energy balance mechanism, this paper analyzed the energy transition law and energy balance mechanism of uniform flow section of open channel with suspended canopy, and has derived the expression of energy borrowing, energy spending, energy transition and relative accumulate values. Using Plew's experimental data of velocity and shear stress, the distribution of energy accumulation along the water depth has been obtained. The result shows that whether at a point or in a cross-section, the energy borrowing is equal to the sum of local energy spending and local energy transition. Energy spending is concentrated in the vegetated layer, reaching the maximum at the interface of vegetation and non-vegetation layers. The total energy transition in the cross section is zero. The energy borrowing in the vegetated layer and the riverbed cannot compensate for the energy spending. So surplus borrowed energy in other parts were needed to be transmitted to these two parts. In the near bed layer, the accumulate values of turbulent energy and energy transition are quite the same, which indicates that most of the energy in this layer is converted into turbulent energy, and only a very small part is converted into heat in order to withstand the resistance in the near bed layer.

Keywords: suspended canopy; steady uniform flow; energy spending; energy transition; energy balance

Experiment study on fracture properties of modified concrete attacked by sulfate corrosion under dry-wet circulation

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Abstract: The ordinary concrete was modified by adding fly ash, slag powder, silica fume and polyester fiber, respectively. Corroded by 5% Na_2SO_4 solution coupling with dry-wet circulation, the concrete beams with notch were performed by means of the three-point bending fracture test to study the cracking resistance behavior of sulfate corrosion concrete. The variation tendencies of *P-CMOD* (load-crack mouth opening displacement) curves, fracture toughness and fracture energy of modified concrete were analyzed. The anti-corrosion toughening coefficient was defined to research the toughening effects of modified concrete contrast to the ordinary concrete under the condition of sulfate attack. The deterioration mechanism of modified concrete was probed at different corrosion periods. The results indicate that the *P-CMOD* curves of modified concrete undergo four stages including damage initial flexure section, elastic proportional section, stable extension stage and softening phase after sulfate corrosion. The anti-corrosion toughening coefficients of modified concrete increase firstly and decrease later varied with the dry-wet circulations. The addition of 25% fly ash improves the fracture toughness of concrete in the early corrosion stage significantly, while polyester fiber and slag have the better effects on enhancing the unstable toughness in the late corrosion period as well as increasing fracture energy. Incorporation of silica fume takes little effects on improving the comprehensive fracture properties.

Keywords: modified concrete; sulfate; dry-wet circulation; corrosion; fracture toughness; fracture energy; anti-corrosion toughening coefficient

Parameter identification and uncertainty analysis of soil water movement model in field layered soils based on Bayes Theory

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Abstract: Soil water movement parameters are the core parameters of water and pollutant migration in unsaturated zone. However, water movement parameters obtained from the indoor steady-state test of the soil samples at the point scale can't accurately reflect the soil water movement characteristics at the field scale under the natural occurring boundary conditions. A Bayesian inference for inversion of soil water retention and hydraulic parameters, based approach DREAM$_{ZS}$ (Differential Evolution Adaptive Metropolis algorithm), was combined with Hydrus_1d to implement model optimization and uncertainty analysis on the data of soil moisture content in field observation (2013 for calibration and 2014 for validation). In order to get the prior information of the parameters in the van Genuchten-Mualem (VGM) model of the soil hydraulic functions, the ROSETTA pedotransfer functions was used. The posterior distribution of the water characteristic parameters was obtained, and modelling performance using the best estimated parameter set and the 95% prediction confidence interval of the model prediction were analyzed. The results show that the Bayes method based on DREAM$_{ZS}$ sampling can be used to identify the soil water characteristic parameters and predict the soil water dynamics at the field scale. The parameter identification results show that the saturated conductivity K_s is the least sensitive, and saturated water content θ_s is the most sensitive and easily identified. The parameter θ_s estimated from the laboratory experiment can be used for the modeling at the field scale. With the increase of soil depth, the higher the PUCI (Percentage of observations bracketed by the Unit Confidence Interval) value, the higher the performance of the model (reliability and accuracy). The prediction uncertainty is mainly caused by model structural uncertainty, and this implies that the effort to improve model prediction credibility in future should focus on diagnosis of model structure.

Keywords: layered soil; Bayes Theory; uncertainty analysis; posterior distribution; DREAM$_{ZS}$

The design theory analysis of the buried lifting integrated sprinkling irrigation device

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Abstracts: Traditional fixed pip sprinkler irrigation has a series of problems such as obstructing cultivation and harvest. A new buried lifting integrated sprinkling irrigation device can solve these kinds of problems and save disassembling time. Based on the principle of shear strength decreasing of wet soil, the maximum resistance, which is needed by the device during its rising processed, and effective driver, are analyzed in the paper. Apart from that, the minimum inlet pressure formula under multi-type soil conditions is given after derivation, and the impact of pipe size on its rising processed is analyzed. The results show that the water pressure in the integrated irrigation equipment without outflow, which ensures that the soil is broken in all types of soil, is 0.7MPa, and the value is far greater than the actual working pressure of sprinkler irrigation. When there is outflow at the top of the sprinkler, the soil is easily broken when the water pressure is only 0.15MPa. With flow out of the top, the minimum water pressure required for breaking ground is inversely related to the diameter of the extension pipe when it is less than 90mm, and the pressure is almost constant when the diameter exceeds 90mm, which provides a theoretical basis for the optimization and design of the water-driven irrigation equipment.

Keywords: buried; lifting; integrated sprinkling irrigation device; design theory analysis

Study on high flood level of Qilishan Waters in changing environment

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Abstract: Qilishan Waters is the confluence of the Dongting Lake into the Yangtze River. Affected by clean water discharging from the Three Gorges Project and upstream Xiluodu Reservoir and Xiangjiaba Reservoir, there are many new changes occurred in this area, such as water flow and sediment transport, river sedimentation and variation of river regime, river flood storage-discharge relationship, flood level and discharge capacity and so on, which have an effect on the flood control and storage pattern in the middle reaches of the Yangtze River, especially in the Dongting Lake. Based on the water-sediment integrate macro mathematical model of the Yangtze River, a locally refined 2D flow-sediment numerical simulation model of Qilishan waters was developed, researching the flood control and storage problems for various typical floods after reservoir group operation under different control levels and different enabled flood detentions. For the type of 1998 flood, through the regulation of Three Gorges dam and raising up 0.5m of the Qilishan control water level, there may be no need to utilize the flood storage areas; however, for the type of 1954 flood, flood storage areas of Dongting Lake and Honghu Lake are still required to be used.

Keywords: changing environment; Dongting Lake; flooding simulation; flood control-storage

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Research on the key technologies of hydraulic new type ship lift

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Abstract: Hydraulic ship lift is a new type of ship lift to which China owns the independent intellectual property rights. By means of theoretical research, physical model test, mathematical model calculation, field test and prototype observation, huge amount of comprehensive and systematic research concerning major technological issues has been displayed in this paper relying on the construction of the world's first Jinghong hydraulic ship lift. A number of breakthroughs have been made in the study of the following technological problems, such as the design theory and method of hydraulic ship lift, hydraulic drive synchronization technology and technology of flow equalization and level stabilization, the chamber tilting mechanisms, theory and technology of anti-tilting under multi-coupling, operation control technology of chamber in unsteady variable speed condition, anti-cavitation technology of high head industrial valves, manufacturing and installation technology of micro gap mechanical synchronous system and so on. The research results have made it possible to operate 70m class hydraulic ship lift steadily, and have laid a solid foundation for the construction of Jinghong ship lift and the popularization and application of this new type of hydraulic ship lift.

Keywords: hydraulic ship lift; hydraulic driving system; mechanical synchronous system; chamber guidance system; operation control

A theoretical method to predict the mechanical properties of concrete considering of the size effect in material

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Abstract: The particle size of coarse aggregates in dam concrete ranges from 5mm to 150mm, consequently, the macroscopic mechanical properties of concrete are easily varied with the aggregate gradation. From the mesoscopic of view, a theoretical method to predict the mechanical properties of concrete considering of the size effect in material is established. In view of the internal structures, the concrete material is regarded as a three-phase composite composed by the coarse aggregate, the mortar matrix and the interfacial transition zone (ITZ). It is assumed that the aggregate is unbroken within the process of loading. The mechanical behavior of the mortar matrix and the ITZ is described by bilinear constitutive models. Based on the theoretical concept of fracture mechanics, a group of theoretical formulae for the determination of mechanical parameters of concrete including the mesoscopic crack length, the macroscopic fracture energy, the uniaxial tensile strength, the characteristic length and the brittleness number are derived. The influences of the mechanical properties of the ITZ and the aggregate gradation/volume on the macroscopic mechanical properties of concrete are analyzed based on the proposed theoretical method.

Keywords: dam concrete; size effect; fracture mechanics; mesomechanics; aggregate gradation; interfacial transition zone

Study of double-G fracture parameters using modified round compact tension method

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Abstract: The double-G fracture model is an extension and supplement of the double-K fracture model. The modified round compact tension method were used to verify whether the new fracture mechanics test method can obtain stable double-G fracture parameters. The double-K fracture toughness calculated by the formula $K=\sqrt{EG}$ was compared with the direct calculation results, in order to further verify the equivalence between the double-G fracture model and the double-K fracture model in describing fracture performance. At the same time, the size effect of two fracture models was studied. The diameters of the 16 test specimens varied from 150mm to 300mm, which were divided into 4 groups. The experimental results show that the value of the double-G parameters measured by the modified round compact tension method is more stable and the dispersion is smaller. The double-G fracture model and the double-K fracture model have high equivalence in describing the fracture properties. When the specimen diameter is greater than 200mm, initial fracture toughness K_{Ic}^{ini} and initial energy release rate G_{Ic}^{ini} have no obvious size effect, unstable fracture toughness K_{Ic}^{un} and unstable energy release rate G_{Ic}^{un} increases with the specimen size increasing,but the growth is small.

Keywords: double-K fracture model; double-G fracture parameters; energy release rate; modified round compact tension specimen

A thought on top-level design of river ecological restoration

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Abstract: River ecological restoration in China has been rapidly developed in recent years. However, there is still a lack of a special top-level design in macro strategy to guide the restoration work. To address this issue, this paper puts forward a thought on top-level design of river ecological restoration by combing and analyzing previous literatures and case studies. This thought contains series of key technical processes as ecological status assessment and identification of stress factors, the determination of restoration base point and target, restoration planning, implementation of ecological restoration, and adaptive management and technology promotion after restoration. The key techniques and implementation suggestions are expounded in detail based on domestic and foreign research results and practical experiences. The results can provide theoretical guidance and reference for the future ecological restoration planning of river, restoration practice and post-restoration management.

Keywords: ecological restoration; top-level design; key technical processes; adaptive management

Numerical simulation of unsteady flow for a pump-turbine in transition cases with large-eddy simulation

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Abstract: This paper is concerned with large-eddy simulation of three-dimensional turbulent flow for a pump-turbine in transition process of increasing or decreasing load operation. The details of dynamical physics of the flow structures with opening variation of the moving guide vane are well captured. The vorticity distributions in the blade turbine passage are significantly distinguished. The flow characteristics in case of water pump or electricity generation in off-design conditions are obtained. This work shows the relations between flow coming angle of attack at the blade let and the vortex structures in the blade passage. Therefore, an identification method of the horseshoe vortex in the blade passage is obtained, and comparative analyses of the vortex structures in the various operation conditions are given. The results show that the flow stability of a pump-turbine is closely related to the evolution characteristics of the flow structures in different operation conditions, and in the transition process of increasing or decreasing load, the scales and distribution ranges of the vortex structures become greater with time and the flow regimes are more unstable.

Keywords: pump-turbine; large eddy simulation; transient process; channel vortex; flow characteristics

Experimental research on fish eggs' movement using particle tracking velocimetry technique

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Abstract: The study of fish eggs' movement is a mechanical basis for understanding the rule of fish eggs' drifting and dispersing in natural rivers. It is of great significance in the estimation of early-stage fish abundance, the evaluation of spawning ground location and the ecological restoration of fish habitat. In order to reveal the characteristics, the main impact factors and impact mechanism of fish eggs' movement under the steady uniform flow in open channel, 20 groups of flume experiments with varying water depths and velocities were carried out and 200 videos of fish eggs' movement (eggs' diameter=4mm, specific gravity=1.01) were recorded and processed by particle tracking velocimetry (PTV) technique, a theoretical derivation of eggs' movement equations was also performed in this paper. The results show that the main impact factors of fish eggs' movement are the flow velocity, the fish eggs' specific gravity, the eggs' diameter and the egg' initial velocity. The eggs' longitudinal velocity is linear increasing with the increasing flow longitudinal velocity and the fitting linear coefficient is 0.73 which meant the eggs' longitudinal velocity is about 0.73 times to the flow longitudinal velocity. The eggs' vertical velocity is mainly affected by the eggs' specific gravity and diameter, and has no significant relationship with the flow longitudinal velocity. In the lower velocity condition, the trajectories of eggs' movement had a linear decrease trend and the slope of trajectories slowed down with the increasing flow velocity. When the velocity increased to 0.93 m/s, the trajectory changed from simple linear sinking to the wave-and-roll type sinking, and some individual eggs jumped suddenly. The impact of flow depth on the eggs' velocity and trajectory is relatively small. The effect of eggs' initial velocity on the eggs' longitudinal vertical velocities were only in the initial short time.

Keywords: fish eggs' movement; flume experiment; theoretical derivation; PTV technology; impact factors; impact mechanism

Assessing the swimming ability and performance of Schizothorax oconnori to cross velocity barriers in fishway

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Abstract: The ability of fish to cross velocity barriers plays an important role in the design process of a fishway. Various swimming speed indicators and behaviors of fishes were mainly determined by tests conducted in closed swim chambers, where current conditions and fish performance are different from that of fishways. Therefore, it is necessary to explore a new experimental protocol of which the experimental channel has similar flow field with fishway to study the swimming ability. Firstly, the critical swimming speed (101.01 ± 20.86cm/s) and the burst swimming speed (196.94 ± 21.80cm/s) of fish were acquired in swim chambers by velocity increment tests. Secondly, based on the critical swimming speed of fish and the designed flow speed at vertical slot of Zangmu Hydropower Station's fishway (110.00cm/s), an experimental channel with vertical slots for testing volitional swimming ability of fish was built by setting different trapezoid barriers in the channel. After this, the swimming tests of Schizothorax oconnori to cross water velocity barriers were carried out with two different barrier layouts. For one layout, the channel has four steps in two gradients (the flow speed in velocity barrier of condition 1 was 101.55±14.87 cm/s, while condition 2 was 114.63±24.28 cm/s), for the other layout, the channel has only one step (the flow speed in the 160 cm long velocity barrier of condition 3 was 137.45±17.63 cm/s). The fish in condition 1 has a success rate of 82.05% to cross four step barrier while it was 84.62% in condition 2; it costs fish 0.52±0.34s in condition 1 and condition 2 to swim continuously to cross the slot which has flow speed greater than critical swimming speed; 93.33 % fish in condition 3 cross the single step barrier successfully in a swimming speed of 209.43±21.76 cm/s; the swimming speeds(214.01±30.64 cm/s)in all three conditions were not significantly different from burst swimming speed of fish (P>0.05). The swimming trajectories of fish and the corresponding flow field show that the time cost and path length for fish to swim upstream is closely related to the path fish choose. Fish reduce its time cost and path length to swim upstream by taking advantage of flow which is in the same direction with fish movement. This method and result of this research could provide reference for fishway design, modification and evaluation.

Keywords: Schizothorax oconnori; fishway; the ability to cross velocity barriers; the volitional swimming performance; the swimming trajectories; water velocity vectors